# Blazars through Sharp Multi-Wavelength Eyes.

### Málaga (Spain). 30 May – 3 June, 2016.

## Program

## Sunday, May 29

19:00 Early registration
20:00 Wellcome cocktail at Hotel Pueblo Camino Real.

## Day I. Monday, May 30.

08:00 Registration opens

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08:55 - 09:00 Greetings
09:00 - 09:25 Opening talk: "A lifetime of blazars". Esko Valtaoja

**Jet Formation** (Chair: Celotti)

09:25 - 09:50 "Probing the Jet-Accretion Flow Connection with the Event Horizon Telescope". Dimitrios Psaltis (Invited)
09:50 - 10:15 "Jets and accretion in blazars". Gabriele Ghisellini (I)
10:15 - 10:30 "Multiwavelength Variability in Jet and Disk Dominated GRMHD Models". Feryal Ozel
10:30 - 10:45 "VLBA+LMT+GBT observations indicate asymmetry in 3mm emission of Sgr A*". Cornelia Mueller
10:45 - 11:00 "Evolution of Global Relativistic Jets: Collimations and Expansion with kKHI and the Weibel Instability". Ken-Ichi Nishikawa

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11:00 - 11:30 Coffee break

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**Jet Physics and Particle Acceleration** (Chair: Georganopoulos)

11:30 - 11:55 "Particle acceleration in magnetically dominated jets". John Kirk (I)
11:55 - 12:20 "Consequences of proton acceleration in blazar jets". Apostolos Mastichiadis (I)
12:20 - 12:45 "Powers and magnetization of blazar jets". Marek Sikora (I)
12:45 - 13:00 "Relativistic Turbulent Reconnection and Application to Jet Acceleration". Makoto Takamoto

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13:00 - 15:00 Lunch break

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**Jet Physics and Dynamics I** (Chair: Asada)

15:00 - 15:25 "Magnetized relativistics jets: exploring their internal structure with numerical simulations". J. M. Martí (I)
15:25 - 15:50 "Multifrequency Blazar Microvariability as a Tool to Investigate Relativistic Jet Flow". Jim Webb (I)
15:50 - 16:05 "Applying relativistic reconnection to blazar jets". Krzysztof Nalewajko
16:05 - 16:20 "Magnetic dissipation in relativistic jets". Yosuke Mizuno

16:20 - 16:35 "Theoretical Study Of The Effects Of Magnetic Field Geometry On The High-Energy Emission Of Blazars". Manasvita Joshi

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16:35 - 17:00 Coffee break

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**Jet Physics and Dynamics II** (Chair: Readhead)

17:00 - 17:25 "AGN Jet Kinematics on Parsec-Scales". Matt Lister (I)
17:25 - 17:50 "The Radio Jet of OJ 287". Marshall Cohen (I)
17:50 - 18:15 "Recent progress on understanding the large scale jets of powerful Quasars". Markos Georganopoulos (I)
18:15 - 18:30 "Proper Motions of Jets on the Kiloparsec Scale: New Results from HST". Eileen Meyer
18:30 - 18:45 "Shapes of AGN jets on scales from parsecs to hectoparsecs". Alexander Pushkarev
18:45 - 19:00 "The global structure of the archetypical quasar 3C 273". Kazu Akiyama

# Day II. Tuesday, May 31.

**Probes of Blazar Jets with the Finest Angular Resolution I** (Chair: Kellermann)

09:00 - 09:25 "mm-VLBI observations of AGN". Thomas Krichbaum (I)
09:25 - 09:50 "Observing Active Galactic Nuclei with the Event Horizon Telescope". Vincent Fish (I)
09:50 - 10:15 "Resolving Magnetic Fields near the Event Horizon of a Black Hole". Michael Johnson (I)
10:15 - 10:30 "First 3 mm-VLBI imaging of the two-sided jet in Cygnus A. Zooming into the launching region". Bia Boccardi
10:30 - 10:45 "Probing the inner the jet of M87 with GMVA observations at 86 GHz". Jae-Young Kim
10:45 - 11:00 "mm VLBI monitoring of NGC1052: Dynamics in a twin-jet system at high angular resolution". Anne-Kathrin Baczko

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11:00 - 11:30 Coffee break

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**Probes of Blazar Jets with the Finest Angular Resolution II** (Chair: Marscher)

11:30 - 11:55 "What have we learned from the RadioAstron survey of AGN cores so far?". Yuri Kovalev (I)
11:55 - 12:20 "Probing the innermost regions of AGN jets and their magnetic fields with RadioAstron". José L. Gómez (I)
12:20 - 12:45 "What's there in Jets: Shocks and Threads, of Cords and Frets?". Andrei Lobanov (I)
12:45 - 13:10 "Space-VLBI observations of nearby radio galaxies with RadioAstron". Tuomas Savolainen (I)
13:10 - 13:25 "The evolution of the nuclear structure of 3C84 at sub-mas resolution". Gabriele Giovannini

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13:25 - 15:10 Lunch break

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**Multi-wavelength Studies of Blazars Ia** (Chair: Ghisellini)

15:10 - 15:35 "Spectral and Polarization Signatures of Relativistic Shocks in Blazars". Markus Böttcher (I)
15:35 - 16:00 "Polarization signatures of AGN jets". Maxim Lyutikov (I)
16:00 - 16:25 "The Power of Simultaneous Multi-Frequency Observations for mm-VLBI and Astrometry". Maria Rioja (I)
16:25 - 16:40 "Interstellar Scintillation and Scattering of Micro-arc-second AGN". David Jauncey
16:40 - 16:55 "Extreme blazars as counterparts of IceCube neutrinos". Paolo Padovani

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16:55 - 17:25 Coffee break

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**Multi-wavelength Studies of Blazars Ib** (Chair: M. Aller)

17:25 - 17:50 "Very fast gamma-ray variability and Multi-wavelength view of 3C279 during outbursts in 2013-2015". Masaaki Hayashida (I)
17:50 - 18:05 "High Energy flares of FSRQs: the connection of flaring states with the accretion disk luminosity". Luigi Pacciani
18:05 - 18:20 "A parsec scale multi-frequency polarimetric analysis of the TeV blazar Mrk 421". Rocco Lico
18:20 - 18:35 "Robopol: optical polarization-plane rotations in blazars". Dmitry Blinov

# Day III. Wednesday, June 1.

**Multi-wavelength Studies of Blazars II** (Chair: Giovannini)

09:00 - 09:25 "Magnetic Kink Instability and Fanaroff-Riley Dichotomy of AGN jets". Alexander Tchekhovskoy (I)
09:25 - 09:50 "Relativistic Jets in AGN: Magnetic Field Structure and Particle Acceleration". Lukasz Stawarz (I)
09:50 - 10:15 "Radiative Transfer Modeling of Radio-band Linear Polarization Data as a Probe of the Physical Conditions in the Jets of Gamma-ray Flaring Blazars". Margo Aller (I)
10:15 - 10:30 "Exploring into the inner jet regions of BL Lac 0716+714 through intra-day optical photo-polarimetric observations". Gopal Bhatta
10:30 - 10:45 "Multi-Timescale Variability in Gamma-ray Blazars". Stefan Larsson

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10:45 -11:15 Coffee break

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**Magnetic Field and Polarization I** (Chair: Ros)

11:15 - 11:40 "Magnetic Fields and Polarization in Blazar jets: progress since 2013". John Wardle (I)
11:40 - 12:05 "Polarization Variability During OutBursts". Hugh Aller (I)
12:05 - 12:30 "The Origin and Global Structure of the Magnetic Fields of AGN Jets". Denise C. Gabuzda (I)
12:30 - 12:45 "Exploring the magnetic field configuration close to central engines using GMVA". Bindu Rani

12:45 - 13:00 "Through The Looking Glass: Faraday Conversion in Turbulent Blazar Jets". Nicholas Macdonald

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13:00 - 13:30 Discussion of Posters

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**Free afternoon (see organized social events)**

# Day IV. Thursday, June 2.

**Magnetic Field and Polarization II** (Chair: Wardle)

09:00 - 09:25 "Magnetic field and polarization in AGN jets". Robert Laing (I)
09:25 - 09:50 "Magnetic Fields in Blazar Jets: Constraints from Full Stokes Observations". Daniel Homan (I)
09:50 - 10:15 "Sharp Polarimetric Eyes: More Trees than Forest?". Paul Smith (I)
10:15 - 10:30 "Robopol: fast cadence optical polarisation monitoring of an unbiased sample of blazars". Emmanouil Angelakis
10:30 - 10:45 "TimeTubes: Visualization of polarization variations in blazars". Makoto Uemura

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10:45 - 11:15 Coffee break

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**Multi-wavelength Studies of Blazars IIIa** (Chair: McHardy)

11:15 - 11:40 "A Gamma-Ray View on Multi-Wavelength Studies of Blazars". Stefan Wagner (I)
11:40 - 12:05 "VHE blazar studies after a decade of H.E.S.S., MAGIC and VERITAS". Wystan Benbow (I)
12:05 - 12:30 "Mrk421 and Mrk501 as high-energy physics laboratories to study the nature of blazars". David Paneque (I)
12:30 - 12:45 "Blazar Jets: insights from Radio and Gamma-ray Light Curves". Timothy Pearson
12:45 - 13:00 "The connection between the radio jet and the gamma-ray emission in CTA102 and 3C120". Carolina Casadio
13:00 - 13:15 "Origin of the gamma-ray emission in AGN jets: the case of 3C 279". Sebastian Kiehlmann

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13:15 - 15:00 Lunch break

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**Multi-wavelength Studies of Blazars IIIb** (Chair: Junhui)

15:00 - 15:25 "Faraday Rotation in Parsec-Scale AGN Jets". Talvikki Hovatta (I)
15:25 - 15:50 "Photometric and polarimetric studies of active galactic nuclei in St. Petersburg University". Valeri Larionov (I)
15:50 - 16:15 "Multi-wavelength studies of blazars BL Lac and 3C454.3". Ann Wehrle (I)
16:15 - 16:30 "Flaring gamma-ray emission from high redshift blazars". Monica Orienti

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16:30 - 17:00 Coffee break

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**Multi-wavelength Studies of Blazars IV** (Chair: Miller)

17:00 - 17:25 "The radio/gamma-ray connection from 120 MHz to 230 GHz". Marcello Giroletti (I)
17:25 - 17:50 "Multifrequency studies of active galactic nuclei in the Planck satellite era". Anne Lahteenmaki (I)
17:50 - 18:15 "Blazars at short millimeter wavelenghts: Total flux and polarimetry". Iván Agudo (I)
18:15 - 18:40 "The VLBA-BU-BLAZAR program". Svetlana Jorstad (I)
18:40 - 18:55 "Spectral evolution of flaring blazars from numerical simulations". Christian Fromm

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**20:00 - 00:15 Conference dinner**

# Day V. Friday, June 3.

**Non-blazar AGN** (Chair: Vermeulen)

09:00 - 09:25 "Multiwaveband Observations of non-blazar AGN". Ian McHardy (I)
09:25 - 09:50 "Blazar-Like Radio Loud Narrow-Line Seyfert 1 Galaxies". Dick Miller (I)
09:50 - 10:15 "Non-Blazar Active Galactic Nuclei". Teddy Cheung (I)
10:15 - 10:30 "Spine/Sheath structure of M87 jet". Keiichi Asada
10:30 - 10:45 "A panchromatic view of relativistic jets in narrow-line Seyfert 1 galaxies". Fillipo D'Ammando

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10:45 -11:15 Coffee break

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**Non-blazar AGN II** (Chair: Lister)

11:15 - 11:40 "Non Blazar Quasars". Ken Kellerman (I)
11:40 - 12:05 "The structure and propagation of the misaligned jet M87". Kazuhiro Hada (I)
11:05 - 12:30 "Observations of the Structure and Dynamics of the Inner M87 Jet". Craig Walker (I)
12:30 - 12:45 "Hidden parents of high-z blazars: quenching and dark bubbles". Tullia Sbarrato
12:45 - 13:00 "30 years on ... how MG85 came about". Walter Gear (I)
**13:00 - 13:30 "Variability of Blazars and Blazar Models over 38 Years". Alan P. Marscher's**

**END of the symposium**

# Blazars through Sharp Multi-Wavelength Eyes.

**Málaga (Spain). 30 May – 3 June, 2016.**

## Abstracts

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Consejo Superior de Investigaciones Científicas

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BOSTON UNIVERSITY

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## TALKS

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### Agudo, Iván

*Blazars at short millimeter wavelenghts: Total flux and polarimetry. (I)*

POLAMI (a Polarimetric AGN Monitoring at the IRAM 30m Telescope), is the first long term 3 and 1.3mm full-polarization monitoring program for bright gamma-ray blazars. Our program, using the XPOL polarimeter, is operating since mid 2007. The project has accumulated almost 8 years of data acquired on a bi-weekly basis, and is now adequate for the study of the long-term time-dependent properties of the total flux and polarized emission of the ~40 sources that were observed more intensively. In this talk, we will focus on the most salient results from the data. These results include from sharp enhances of linear polarization degree, frequently related to total flux and linear polarization angle rotations, on time scales much shorter than those for total flux flares; to clear turns of linear polarization angle by more than 180 deg. on time scales of months (often related to even quicker gamma-ray and optical flares, and high optical polarization peaks); and circular polarization detections and even circular polarization variability on the most intense objects.

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### Akiyama, Kazu

*The global structure of the archetypical quasar 3C 273.*

We report on multi-frequency observations of the archetypal quasar 3C 273 performed with the VLBA at 1.4/15/22/43 GHz, the VLA at 5/8/22 GHz, and MERLIN at 1.6 GHz. The observations provide transverse resolution over a broad range from subparsec to kiloparsec scales, allowing us to profile the jet width as a function of core distance, as has previously been done for some radio galaxies (e.g. M87, 3C 84, and Cyg A). For the first time in a quasar jet, we have discovered a parabolic profile, which transitions to a conical profile at a distance of ~10^5-10^6 Rs from the 7-mm core. The similarity in these properties to the much lower-powered radio galaxy M87 suggests a universality of jet acceleration and collimation among AGNs with different accretion rates of the central super-massive black hole. Future ultra-high-resolution VLBI observations with ALMA at 86 and 230 GHz will be able to effectively constrain the active collimation region and the launching point of the visible jet at the end the collimation profile in 3C 273 and other AGNs.

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## Aller, Hugh

*Polarization Variability During OutBursts. (I)*

The University of Michigan 26-meter telescope studied the polarization extragalactic sources at centimeter wavelengths for four decades, starting with the discovery of time variability by Dent in 1965. Initial polarization observations at 8 GHz were expanded to include observations at 14.5 GHz and 4.8 GHz, and starting in 1978 the telescope was placed under computer control which permitted observations to be made continuously, subject only to weather constraints. Extensive circular polarization measurements at 4.5 and 8.0 GHz were restarted in the 1990's, which extended the work by Hodge. One object, 3C 279, exhibited V as high as one percent. The majority of the objects remained significantly below this level during our period of observation.

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## Aller, Margo

*Radiative Transfer Modeling of Radio-band Linear Polarization Data as a Probe of the Physical Conditions in the Jets of Gamma-ray Flaring Blazars. (I)*

Since the mid 1980s the shock-in-jet model has been the preferred paradigm to explain radio-band flaring in blazar jets. The total flux density variability alone can be explained by a variety of scenarios, but the linear polarization spectral variability is a crucial model discriminant sensitive to the degree of order and topology of the magnetic field in the emission region, and, in particular, to the jet viewing angle. We describe our radiative transfer model which incorporates relativistically-moving shocks, and illustrate how the 4.8, 8, and 14.5 GHz spectral data from the University of Michigan monitoring program can be used in combination with the model to determine the jet flow conditions and shock attributes. We demonstrate the sensitivity of the model parameters to the linear polarization variability using 1156+295 and 0716+714, blazars with different jet flow and shock properties, as examples. We present results from modeling three epochs of flaring in OT 081, including the originally-modeled 1985 flare, which were carried out to identify temporal evolution in the jet. We compare our model results for key parameters with those in the literature based on commonly-used, simple analytic expressions and find a smaller range even when observations separated by decades are modeled; for example, our tightly- constrained viewing angles are 1.1 to 1.7 degrees. While connections between VLBI component ejections and the onset of flares associated with shocks have been found in some sources, we do not find a consistent relationship between shock onset and 43 GHz structural changes in this blazar.

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## Angelakis, Emmanouil

*Robopol: fast cadence optical polarisation monitoring of an unbiased sample of blazars.*

We are presenting the highlights of the R-band polarization program RoboPol that has been monitoring a sample of gamma-ray-loud (GL) and one of gamma-ray-quiet (GQ) sources with cadence of days. We discuss both the amplitude domain as well as the angle domain findings. Motivated by the discovery that blazars occasionally display smooth and long rotations of their optical polarization plane, we designed, funded, constructed and are operating a 4-channel optical polarimeter for the systematic study of the phenomenon. The program has already completed its first 3 observing seasons with the monitoring of an unbiased sample of 65 GL taken form a flux-limited sub-set of 2FGL and 15 GQ sources selected from the 15-GHz OVRO monitoring program. The main goals of the program has been: (a) the temporal behavior of the polarization of blazars; (b) the quantification of the polarization parameters of GL sources and the search for possible systematic differences with those of GQ sources; (c) the systematic study of the polarization angle rotations and their association with the activity MeV – GeV energy band, and the search for possible physical connection between them. Some findings that will be discussed; Amplitude domain: we discover that GL sources are more polarized (as a population) than GQ ones, at a level beyond the 3σ. We also find that the higher the SED synchrotron peak frequency the lower the polarization and its variability. We also find that the polarisation angle seems to be more stable with increasing peak frequency which implies a helical topology of the field to be dominant. The polarization shows a positive correlation with the flux density variability while a negative one with polarisation the variability. Angle domain: we find that the brightest gamma-ray flares tend to be closer in time to rotation events, an indication that two separate mechanisms produce rotations. We show that it is unlikely that all the observed rotations are produced by random walk of the polarization vector. Additionally it is highly unlikely that none of our rotations is physically connected with an increase in gamma-ray activity. The average fractional polarization during the rotations tends to be lower than that in a non-rotating state. The average fractional polarization during rotations is correlated with the rotation rate of the polarization plane in the jet rest frame.

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## Asada, Keiichi

*Spine/Sheath structure of M 87 jet*

We will show images of M 87 with GMVA at 86 GHz and VSOP at 1.6 and 5 GHz. In order to investigate the innermost region of the M 87, we conducted GMVA observation in 2014 and also reduced VSOP archival data. We measured jet streamlines with those images, and those are reasonably agreed with previous measurements by Asada & Nakamura (2012) and Nakamura and Asada (2013). However, in VSOP images, additional ridge structure is clearly seen in addition to the double ridge structure. This

central ridge line is much brighter and longer at 1.6 GHz compare to that at 5 GHz. Also it totally disappears at 86 GHz image. The origin of this newly recognized central ridge can be explained with central spine by BZ jet.

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## Baczko, Anne-Kathrin

*Millimeter VLBI monitoring of NGC1052: Dynamics in a Twin-Jet System at high angular resolution.*

The LINER galaxy NGC1052 is an exceptional case showing a double-sided jet system at cm and mm radio wavelength. Due to its close distance of 20Mpc it is an ideal target to study the inner subparsec scales around the central engine. We present high resolution mm VLBI observations given insight to the jet forming region. We recently analysed one 86GHz GMVA observation revealing one central feature and two fainter jets to the east and the west. Interpreted as a blend of both jet bases, this leads to a magnetic field strength at 1Rs between 3e2G and 7e4G. Mm-wavelength observations peer through the free-free absorbing torus, that blocks our view onto the western jet base at cm-wavelength. We were able to localize the absorbing structure more precisely than before by analysing the spectrum between 22GHz and 43GHz with quasi-simultaneous observations over 4 years. This sets the central feature, observed at 43GHz and 86GHz, to the west of the 22GHz jet-core. Furthermore, the 43GHz images reveal an asymmetry between the two jets in NGC1052, raising the question whether asymmetric jet production, changes of the orientation angle or other intrinsic asymmetries could explain the observations.

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## Benbow, Wystan

*VHE blazar studies after a decade of H.E.S.S., MAGIC and VERITAS. (I)*

Third-generation detectors of astrophysical VHE (E>100 GeV) gamma rays began full-scale operation in the mid-2000's. These arrays of atmospheric-Cherenkov telescopes, H.E.S.S., MAGIC and VERITAS, dramatically changed the view of the VHE sky. More than 60 active galactic nuclei (AGN), primarily blazars, are now known to emit VHE photons, and the VHE horizon extends to a redshift of at least $z \sim 1$. The gains in VHE sensitivity, along major efforts in coordinating simultaneous observing with improved facilities at lower energy, have also enabled significant advances in the understanding of VHE blazars through both multi-wavelength correlation studies and spectral-energy-distribution modeling. An overview of the current status of VHE blazar studies will be presented along with a selection of recent highlights.

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## Bhatta, Gopal

*Exploring into the inner jet regions of BL Lac 0716+714 through intra-day optical photo-polarimetric observations.*

Blazars are known to exhibit variability on diverse timescales, ranging from few minutes to several years, across the entire electromagnetic spectrum. Among many, BL Lac S5 0716+714 is one of the best studied blazars detected by most of the current instruments operating from radio through Tev energy range. For long, its nearly 100% duty cycle has fascinated the observers and theorists alike. In particular, the sub-hour scale variability known as intra-day or microvaribily has been extensively studied in optical photo-polarimetric bands for past 25-30 years. Here we present the summary of our optical microvariability studies over past few years including the recent extended multi-frequency photo-polarimetric observation campaign lasting few days. The results show that the source often displays a fast variability, with an amplitude as large as 0.3 mag within few hours, superimposed on slower modulation in the flux in the the timescales of few days. The color variability is also observed in similar time scales and are often characterized by “bluer-when-brighter” trend. Similarly, variability in polarization degree sometimes appears in phase with flux variability whereas other times they appear uncorrelated. During the whole earth blazar telescope campaign in 2014, we detected a possible $\sim 6-8$ h quasi-periodic oscillations along with a sudden “switch-off” in the activity lasting about for 6 hrs. In addition, the modeling of individual 'micro-flares' strongly suggest that the phenomenon of microvariabily can be best explained by the convoluted emission from the turbulent environment in the jet. Besides, analysis on some of the well resolved micro-flares exhibiting high degree of polarization point towards a complex magnetic geometry pervading the jet with possible presence of small scale highly ordered magnetic field enhanced regions so-called 'magnetic islands'.

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## Blinov, Dmitry

*Robopol: optical polarization-plane rotations in blazars*

We present some results of our studies of the optical polarization-plane rotations in blazars detected by RoboPol, a monitoring programme of an unbiased sample of blazars specially designed for effective detection of such events. The entire set of rotation events discovered during three years of observations is analysed with the aim to determine whether these events are inherent to all blazars. It is found that the frequency of the polarization plane rotations widely vary among blazars. This variation can neither be explained by a difference in the relativistic boosting nor by selection effects caused by a difference in the average fractional polarization. Therefore, the rotations are characteristic only for a subset of blazars. We also searched for possible correlations between average parameters of the polarization-plane rotations and average parameters of polarization, with the following results: (1) there is no statistical association of the rotations with contemporaneous optical flares; (2) the average fractional polarization during the rotations tends to be lower than that in a non-rotating state; (3) the average fractional polarization during rotations is correlated with the

rotation rate of the polarization plane in the jet rest frame.

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## Boccardi, Bia

*First 3 mm-VLBI imaging of the two-sided jet in Cygnus A. Zooming into the launching region*

We present for the first time Very-Long-Baseline Interferometry images of the radio galaxy Cygnus A at the frequency of 86 GHz. Thanks to the high spatial resolution of only ∼200 Schwarzschild radii (RS), such observations provide an extremely detailed view of the nuclear regions in this archetypal object and allow us to derive important constraints for theoretical models describing the launching of relativistic jets. A pixel-based analysis of the jet outflow, which still appears two-sided on the scales probed, was performed. By fitting Gaussian functions to the transverse intensity profiles, we could determine the jet width in the nuclear region. The base of the jets appears wide. The minimum measured transverse width of ∼(227 ± 98) RS is significantly larger than the radius of the Innermost Stable Circular Orbit, suggesting that the outer accretion disk is contributing to the jet launching. The existence of a faster and Doppler de-boosted inner section, powered either from the rotation of the inner regions of the accretion disk or by the spinning black hole, is suggested by the kinematic properties and by the observed limb brightening of the flow.

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## Boettcher, Markus

*Spectral and Polarization Signatures of Relativistic Shocks in Blazars . (I)*

This talk will present recent results on self-consistent simulations of diffusive shock acceleration and radiation transfer in relativistic jets, considering spectral and time-dependent polarization signatures. Inferences on the nature of hydromagnetic turbulence developing behind relativistic shock fronts are deduced from the spectral signatures, while the time-dependent polarization signatures allow for diagnostics of the role of magnetic fields in the particle acceleration process.

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## Casadio, Carolina

*The connection between the radio jet and the gamma-ray emission in the blazar CTA102 and the radio galaxy 3C120*

We present multi-wavelength studies of the blazar CTA102 and the radio galaxy 3C120 during unprecedented γ-ray flares for both sources. The Fermi Large Area Telescope registered in September-October 2012 an extraordinary bright γ-ray outburst in the

quasar CTA102, and between December 2012 and October 2014 a prolonged γ-ray activity in the radio galaxy 3C120. In both studies the analysis of Fermi data has been compared with a series of 43 GHz VLBA images from the VLBA-BU-BLAZAR program, providing the necessary spatial resolution to probe the parsec scale jet evolution during the high energy events. In the case of 3C120, in order to extend the observing period covered by radio data, we also used 15 GHz VLBA data from the MOJAVE sample. Although these two objects represent very different classes of AGN, we found they have similar properties during the γ-ray events. The γ-ray flares are associated with the passage of a new superluminal knot through the mm VLBI core, but not all ejections of new components lead to γ-ray events. Both in CTA102 and in 3C120, γ-ray events occurred only when the new components are moving in a direction closer to our line of sight. We locate the γ-ray dissipation zone a short distance downstream of the radio core but outside of the broad line region, suggesting synchrotron self-Compton scattering as the probable mechanism for the γ-ray production. In addition, during the multi-wavelength outburst observed in CTA102, the optical polarized emission displayed intra-day variability and a clear clockwise rotation of the polarization vectors, which we associate with the path followed by the knot as it moves along helical magnetic field lines.

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## Cheung, C. C. Teddy

*Non-Blazar Active Galactic Nuclei. (I)*

An overview of Fermi-LAT results on the subset of non-blazar active galactic nuclei with high-energy GeV gamma-ray emission originating from outside the traditional “blazar-nucleus” will be presented. Particular attention will be given to GeV emission from radio lobes as well as insights gained from gamma-ray variability and timing observations. Some considerations for what results may be anticipated from further Fermi-LAT GeV observations as well as by extending the frequency coverage to MeV energies with a future mission.

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## Cohen, Marshall

*The Radio Jet of OJ 287. (I)*

At 43 GHz, the inner jet of the blazar OJ 287 displays variations in Position Angle (PA) on time scales of a year ("wobble"), in addition to a "jump" in PA of about 120 degrees (Agudo et al 2012). At 15 GHz we see a similar wobble and jump, but the jump occurs about 5 years later than at 43 GHz. The time lag, presumably, is caused by a combination of optical depth and angular resolution effects. At both frequencies, the flux density of the core rises by a factor of about 3 and then falls abruptly at the PA jump; part of this, at least, is due to the blend of the core with the emerging new component that defines the new PA. Agudo et al (2012) suggest that the jump occurs when the jet (nearly) crosses

the line-of-sight. This seems likely, but requires the jet to be curved. The innermost pre-jump component (No 10) appears to be a recollimation shock that is advected with the transverse motions of the jet, and may be the seat of several superluminal components.

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## D'Ammando, Filippo

*A panchromatic view of relativistic jets in narrow-line Seyfert 1 galaxies*

The discovery by the Large Area Telescope on board Fermi of variable gamma-ray emission from radio-loud narrow-line Seyfert 1 (NLSy1) galaxies revealed the presence of a possible third class of AGN with relativistic jets in addition to blazars and radio galaxies. Considering that NLSy1 are usually hosted in spiral galaxies, this finding poses intriguing questions about the nature of these objects and the formation of relativistic jets. We report on a systematic investigation of the gamma-ray properties of a complete sample of radio-loud NLSy1, including the detection of new objects, using 7 years of Fermi-LAT data with the new Pass 8 event-level analysis. In addition we discuss new results about the host galaxy, black hole mass, and the radio-to-very-high-energy properties of the gamma-ray emitting NLSy1 in the context of the blazar scenario and the unification of relativistic jets at different scales.

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## Fish, Vincent

*Observing Active Galactic Nuclei with the Event Horizon Telescope (I)*

Originally developed to image the shadow region of the central black hole in Sagittarius A* and in the nearby galaxy M87, the Event Horizon Telescope (EHT) provides deep, very high angular resolution data on other AGN sources too. The challenges of working with EHT data have spurred the development of new image reconstruction algorithms. This talk will briefly review the status of the EHT and its utility for observing AGN sources, with emphasis on imaging techniques that offer the promise of better reconstructions at 1.3 mm and longer wavelengths.

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## Fromm, Christian

*Spectral evolution of flaring blazars from numerical simulations*

We performed relativistic hydrodynamic simulations of over-pressured and pressure matched jets. Once a steady state is reached we injected perturbations at the jet nozzle and computed the non-thermal emission taking adiabatic and synchrotron losses into account. The analysis of the computed single-dish light curves and VLBI observations show clear signatures which can be used to distinguish over-pressured jets from

pressure matched jets.

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## Gabuzda, Denise

*The Origin and Global Structure of the Magnetic Fields of AGN Jets. (I)*

Theoretical models for the origin of the magnetic fields of AGN jets have long predicted that they should have a helical structure, at least on small scales, due to the winding up of a seed field by the differential rotation of the accretion disk combined with the jet outflow. There has been less clarity about how far out this helical field component persists, with some pictures having it disrupted, for example, in a standing shock associated with the observed VLBI core at mm wavelengths. Extensive analyses based on a variety of multi-wavelength radio-interferometric polarization observations have now conclusively demonstrated that a helical field component can persist out to parsec, decaparsec and even kiloparsec scales; by kiloparsec scales, this has probably evolved into a close to purely azimuthal field. The direction of the azimuthal field provides information about the dominant current in the jet - inward or outward. There is now conclusive evidence that the jet current is predominantly inward on parsec scales, but outward on kiloparsec scales. One way to understand this is if the azimuthal field component detected on the larger scales is associated with a "return field" which represents a smooth continuation of the outgoing helical field but with a reversal in the direction of the azimuthal field component.

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## Georganopoulos, Markos

*Recent progress on understanding the large scale jets of powerful Quasars (I)*

I will discuss recent progress, new insights, and new questions on our understanding of the large scale jets of powerful quasars.

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## Ghisellini, Gabriele

*Jets and accretion in blazars (I)*

I will discuss the spectral energy distribution (SED) of all blazars of the 3LAC catalog of Fermi.
I will update the so called "blazar sequence" from the phenomenological point of view, with no theory or modelling. I will show that i) pure data show that jet and accretion power are related; ii) the updated blazar sequence maintains the properties of the old version, albeit with a less pronounced dominance of the gamma-ray emission; iii) at low bolometric luminosities, two different type of objects have the same high energy power:

low-black hole mass flat spectrum radio quasars and high mass BL Lacs. Therefore, at low luminosities, there is a very large dispersion of SED shapes; iv) in low power BL Lacs, the contribution of the host galaxy is important. Remarkably, the luminosity distribution of the host galaxies of BL Lacs are spread in a very narrow range.

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## Giovannini, Gabriele

*The evolution of the nuclear structure of 3C84 at sub-mas resolution*

I will present and discuss a study on the sub-pc scale radio structure of the radio galaxy 3C84, starting from first VLBI observations to recent results based on space VLBI observations obtained with Radioastron. I will compare these data and the long time monitor in the radio band with results obtained at high frequency in the gamma-ray band. I will use these results to discuss the origin of the jet limb-brightening structure and the restarted activity associated with recent outbursts.

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## Giroletti, Marcello

*The radio/gamma-ray connection from 120 MHz to 230 GHz (I)*

The millimeter wavelength domain is a crucial band to understand the physical properties of blazars and the connection to high energy emission. However, it has been traditionally a difficult task to obtain data in this band. Exploiting the great sensitivity of ALMA, we have observed a sample of 77 gamma-ray blazars detected by Fermi. These blazars have been selected in such a way to constitute an unbiased subset, representative of the third Fermi Large Area Telescope Catalog (3LAC) in terms of blazar types, gamma-ray flux, luminosity, and photon index. We present the results of ALMA observations carried out in 2015 at 230 GHz for this sample, and discuss the relation between the cm, mm, and gamma-ray properties of blazars. In particular, we compare the results to those obtained cross-correlating (gamma-ray) blazar catalogues and the low frequency survey carried out with the Murchison Widefield Array between 120 and 180 MHz, which in turns provide information about the connection between nuclear and extended emission in radio sources.

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## Gómez, José L.

*Probing the innermost regions of AGN jets and their magnetic fields with RadioAstron at tens of microarcseconds resolution (I)*

We present polarimetric 1.3 cm RadioAstron, 7 mm global-VLBI, and 3 mm GMVA observations of a sample of blazars probing the innermost jet regions up to a record

angular resolution of 21 microarcseconds. Comparison of the total and polarized emission across these wavebands allows us to determine the magnetic field structure and strength in the vicinity of the central black hole through Faraday rotation and opacity analysis. It allows us also to probe the brightness temperature, angular sizes, and spectra across and along the innermost jet to determine the physical parameters of the fluid (velocity field, energy density) and that of the non-thermal electron population. This information is used to study how AGN jets are formed, accelerated and collimated, and what is the role played by the magnetic field in these processes.

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## Hada, Kazuhiro

*The structure and propagation of the misaligned jet M87 (I)*

Due to the proximity M87 is a prime target for next-generation high-resolution VLBI (mm-VLBI or space-VLBI) which will enable us to resolve and image the jet formation structure near the black hole at event horizon scales. Moreover, this source is one of the nearest misaligned jets showing variable gamma-ray emission, the observed properties of which are quite similar to blazars. Therefore, high-resolution studies of this jet not only allows us to test jet formation models, but also may help in understanding the nature of distant blazars, which are difficult to directly resolve the scales relevant to the gamma-ray production. In this talk I will present our recent results for the jet formation scales of the M87 jet that were obtained by high-sensitivity VLBI programs. Moreover, I will introduce our new monitoring program of M87 with the KVN and VERA Array (KaVA), which has emerged as a new regularly-operating VLBI facility in East Asia. The initial outcome and future perspective will be presented.

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## Hayashida, Masaaki

*Very fast gamma-ray variability and Multi-wavelength view of 3C279 during outbursts in 2013-2015 (I)*

The Flat Spectrum Radio Quasar 3C279 becomes one of the brightest gamma-ray blazars in the sky. Powerful outbursts producing gamma-ray fluxes higher than 1e-5 ph/cm2/s (>100 MeV) were observed in December 2013, April 2014, and June 2015. The December 2013 outburst showed an unusually hard power-law gamma-ray spectrum (index~1.7), and an asymmetric light curve profile with a few-hour time scale variability, but no flaring activities were observed either X-ray nor optical bands. That outburst could be successfully explained using our second order Fermi acceleration model. The outburst in June 2015 was even more powerful, with an integral flux above 100 MeV of 4e-5 ph/cm2/s, the historically highest even when the EGRET era is included. Concurrently, the soft X-ray flux increased to the highest level ever measured by Swift-XRT. Our analysis of the LAT data revealed minute-scale variability, which is the most rapid among blazers observed by Fermi-LAT. In this talk, I will present the gamma-ray

and multiwavelength observational results of these outbursts from 3C279. I will discuss possible origins of the outbursts, including the synchrotron origin scenario for the gamma-ray emission.

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## Homan, Daniel

*Magnetic Fields in Blazar Jets: Constraints from Full Stokes Observations (I)*

Magnetic fields are believed to play a key role in the initial launching and subsequent acceleration and collimation of relativistic jets of Blazars; however, unique interpretation of polarization observations to help constrain the magnetic field structure and dynamics on parsec scales remains a challenge. A variety of observational and physical effects complicate the analysis of polarization observations, including: MHD turbulence which randomizes and re-orders the field, projection effects which superpose polarization from the back and front of jet, beam depolarization, opacity, and of course, Faraday rotation and depolarization which can occur both internal and external to the jet. We discuss the constraints available from Full Stokes observations of relativistic jets with special attention to the role of circular polarization in addressing these challenges. Produced either as an intrinsic component of the emitted synchrotron radiation, or through a propagation effect produced within the jet plasma, circular polarization is not modified by external Faraday screens and serves as a probe of the magnetic field and particle properties within the jet itself.

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## Hovatta, Talvikki

*Faraday Rotation in Parsec-Scale AGN Jets (I)*

In 2006, we obtained multifrequency radio polarization observations of 191 parsec-scale AGN jets within the MOJAVE program. We detected parsec-scale Faraday rotation in 149 jets, making it the largest statistical sample studied to date. In my talk, I will review the main findings of this statistical study, and also present new results from a follow-up program conducted in 2011, where a sample of seven most interesting sources from the survey were observed with a wider frequency coverage and better sensitivity.

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## Jauncey, David

*Interstellar Scintillation and Scattering of Micro-arc-second AGN*

The Micro-Arcsecond Scintillation-Induced Variability, MASIV, Survey has explored inter-day variability, IDV, of a large number of northern, flat-spectrum, radio AGN. These

data have shown that IDV arises principally from scintillation caused by scattering in the ionized interstellar medium, ISM, of our Galaxy. The sensitivity of interstellar scintillation, ISS, towards source angular sizes has provided a powerful tool for studying the most compact components of radio-loud AGN at microarcsecond, μas, scale resolution.

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## Johnson, Michael

*Resolving Magnetic Fields near the Event Horizon of a Black Hole (I)*

Magnetic fields play a central role in the accretion, emission, and outflow near black holes but have never been directly observed in this region. Yet, because linear polarization of the bright synchrotron emission from galactic cores traces these magnetic fields, polarimetric interferometry with the Event Horizon Telescope (EHT) is capable of imaging these near-horizon fields. I will present EHT observations of the Galactic Center supermassive black hole, Sgr A*. These observations, the first to resolve the polarized emission from Sgr A* at any wavelength, revealed ordered magnetic fields with vigorous activity near the event horizon. I will discuss the emerging capabilities of the EHT to study turbulence driven by the magnetorotational instability, the role of magnetic fields in jet launching, and signatures of magnetically-dominant regions near supermassive black holes.

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## Jorstad, Svetlana

*The VLBA-BU-BLAZAR program (I)*

I will describe a multiwavelength program of monitoring of a sample of bright gamma-ray blazars, which the BU group has carried out over the last 8 years. The program includes monthly monitoring with the Very Long Baseline Array at 43 GHz, optical photometric and polarimetric observations, construction and analysis of UV and X-ray light curves obtained with the RXTE and Swift satellites, and construction and analysis of gamma-ray light curves based on data provided by the Large Area Telescope of the Fermi Gamma-ray Space Telescope. I will present general results about the kinematics of parsec-scale radio jets, as well as the connection between optical polarization parameters and jet structure and between gamma-ray outbursts and radio jet events. I will compare the multi-wavelength behavior during recurrent gamma-ray outbursts in the prominent quasars 1222+216 and 3C454.3. This research has been funded in part by NASA Fermi Guest Investigator grants NNX08AV65G, NNX11AQ03G, and NNX14AQ58G.

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## Joshi, Manasvita

*Theoretical Study Of The Effects Of Magnetic Field Geometry On The High-Energy Emission Of Blazars*

The knowledge of the structure of the magnetic field inside a blazar jet, as deduced from polarization observations at radio to optical wavelengths, is closely related to the formation and propagation of relativistic jets that result from accretion onto supermassive black holes. However, a largely unexplored aspect of the theoretical understanding of radiation transfer physics in blazar jets has been the magnetic field geometry as revealed by the polarized emission and the connection between the variability in polarization and flux across the spectrum. Here, we explore the effects of various magnetic geometries that can exist inside a blazar jet: parallel, transverse, oblique, toroidal, helical, and tangled. We investigate the effects of changing the orientation of the magnetic field, according to the above-mentioned geometries, on the resulting high-energy spectral energy distributions (SEDs) and spectral variability patterns (SVPs) of a typical blazar. We use the MUlti-ZOne Radiation Feedback (MUZORF) model of Joshi et al. (2014) to carry out this study and to relate the geometry of the field to the observed SEDs at X-ray and gamma-ray energies. One of the goals of the study is to understand the relationship between synchrotron and inverse Compton peaks in blazar SEDs and the reason for the appearance of gamma-ray "orphan flares" observed in some blazars. This can be associated with the directionality of the magnetic field, which creates a difference in the radiation field as seen by an observer versus that seen by the electrons in the emission region. This research was supported in part by NASA through Fermi grants NNX10AO59G, NNX08AV65G, and NNX08AV61G, NASA through Swift grants NNX09AR11G, NNX10AL13G, and NNX10AF88G, and by NSF grant AST-0907893.

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## Kellermann, Kenneth

*Non Blazar Quasars (I)*

It has been half a century since the discovery of quasars and the subsequent recognition of the much larger radio quiet quasar population. Although all quasars are thought to contain a SMBH as the source of their enormous OIR luminosity, it has not been clear if the radio loud quasars are a distinctly different class of object from the radio quiet quasars or if they are just the high end of a smooth radio luminosity function, and why only a small fraction of optically selected quasars are strong radio sources. I will discuss the results of a VLA study of quasars selected from the Sloan Digital Sky Survey which suggest that the radio emission from radio quiet quasars is mostly due to star formation in the host galaxy and is not directly related to the SMBH, why previous radio studies were unable to unambiguously recognize the separate population of radio quiet quasars, and I will speculate on the role of relativistic beaming in determining the radio luminosity of quasars.

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## Kiehlmann, Sebastian

*Origin of the gamma-ray emission in AGN jets: the case of 3C 279*

One of the main topics regarding the physics of AGN jets is the origin of the gamma-ray emission. In this talk we present the photometry data set of the archetypical blazar 3C 279 collected by the Quasar Movie Project. These data comprise 140 light curves at more than twenty bands, providing dense sampling in frequency and time domain over more than two years. We estimate the variability power spectra at 26 frequencies and find similar indices of a power-law spectrum at sub-mm bands and X-rays on the one hand and at ultraviolet and gamma-rays on the other hand. Additionally, we find a strong correlation between X-rays and the 1 mm light curve at short variability time scales. We can infer that the X-ray emission site is located at the mm VLBI core and that X-rays are probably produced by synchrotron self-Compton scattering of mm-wavelength synchrotron photons. The correlation between X-rays, gamma-rays, and optical bands exhibits complex behaviour. Time lags between the bands change over time, indicating probably different emission sites and different physical conditions. But we find some indication that the gamma-ray emission site is located, at least occasionally, at the mm VLBI core. Thus, it is at some times located beyond the broad line region, where infrared photons either from the jet itself or from the dust torus may serve as seed photons for the inverse Compton scattering to GeV energies.

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## Kim, Jae-Young

*Probing the inner the jet of M87 with GMVA observations at 86 GHz*

M87 is the closest FR I radio galaxy with a black hole mass of (3-6) billion solar masses. The mass to distance ratio makes M87 the best target to study jet launching and collimation. High spatial resolution imaging with the Global millimeter VLBI Array (GMVA) at 3mm resolves the inner jet region and shows a complex filamentary fine-scale structure at a spatial resolution of only ~6 Schwarzschild-radii. Here we present new results from a GMVA observation of M87 performed in May 2015. Owing to the addition of the sensitive mm-VLBI telescopes, including both IRAM telescopes and the GBT, the observation reveals many new details of the complex jet and core morphology. In our data analysis we compare the results to earlier epochs from previous GMVA sessions. The observed basic source structure appears to remain similar over several years, which is also supported by alternative imaging techniques such as MEM. We discuss our results in the context of the ongoing research on this source.

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## Kirk, John

*Particle acceleration in magnetically dominated jets (I)*

Jets driven by rotating black holes via the Blandford-Znajek mechanism are initially dominated by electromagnetic fields. As they propagate outwards, this domination increases, at least until they can be collimated by interacting with the surrounding medium. In this situation, the dissipation of jet power into relativistic particles and radiation via shock fronts is ineffective. Furthermore, dissipation by reconnection or by conversion into superluminal waves is only posible if the jet contains magnetic field fluctuations on a sufficiently short length-scale. I will present two fluid simulations of the mode conversion process, and show that it accelerates particles to a characteristic energy, above which a power-law spectrum can be produced via the first-order Fermi acceleration mechanism.

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## Kovalev, Yuri

*What have we learned from the RadioAstron survey of AGN cores so far? (I)*

The RadioAstron AGN survey is performed by the 10-m space radio telescope Spektr-R and many sensitive ground radio telescopes in Europe, Asia, USA, South Africa, Australia, Japan at 18, 6, and 1.3 cm and has detected more than 150 AGNs at projected spacings up to 350 000 km (27 Earth diameters). Formal resolution as high as 14 microarcsec has been achieved. Results indicate that many AGN cores are significantly brighter than what was known before. In the same time, extreme brughtness temperature values of 10^15-10^16 K were not observed. Implications of AGN survey results for the physics of AGN jets and interstellar medium will be discussed.

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## Krichbaum, Thomas

*mm VLBI observations to AGN (working title) (I)*

Present status and future outlook on AGN research with mm VLBI.

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## Lahteenmaki, Anne

*Multifrequency studies of active galactic nuclei in the Planck satellite era (I)*

The multi-epoch, single-survey Planck satellite data have given us a rare glimpse of how the radio spectra of active galactic nuclei (AGN) evolve in time. Using Planck and

simultaneous auxiliary radio data, ranging from 1 GHz to 857 GHz, we have assembled spectra for 104 bright northern extragalactic radio sources (most of them AGN) in which the various stages of flare development can be identified. In this talk I review the latest results, including a set of sources showing signs of intrinsic cold dust.

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## Laing, Robert

*Magnetic field and polarization in AGN jets (I)*

I will review what we have discovered from deep imaging of polarized radio emission about the strength and geometry of magnetic fields in AGN jets on parsec and kiloparsec scales. I will pay particular attention to the ways in which we can distinguish between vector-ordered (e.g. helical) and anisotropic, disordered field configurations on various scales.

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## Larionov, Valeri

*Photometric and polarimetric studies of active galactic nuclei in StPetersburg University (I)*

The results of multivawelength studies of a large set of active galactic nuclei, both photometric and polarimetric, obtained in St.Petersburg University during past 50 years, are presented. We also describe some new methods developed to analyse temporal and spectral variability of these sources.

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## Larsson, Stefan

*Multi-Timescale Variability in Gamma-ray Blazars*

The Femi Large Area Telescope has provided a unique set of almost continuous gamma-ray light curves now covering a time span of more than 7 years. These data together with observations in other parts of the spectrum have been used in many investigations of variability and multiwavelength properties of blazars, both in an average sense and during shorter observing campaigns, often associated with flaring episodes. As light curves are further extended the averaged variability and correlation properties can be determined more accurately. But longer light curves also open up the possibility to study the time evolution of these properties and thereby explore the connections between the shorter and longer time scales. With simulations based on present data we will discuss the potential of continuing Fermi-LAT observations to study multi-timescale variability, such as the rms-flux relation and time variations in multi-band correlations.

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## Lico, Rocco

*A parsec scale multi-frequency polarimetric analysis of the TeV blazar Mrk 421*

In this talk I will present a multi-frequency and multy-epoch polarization analysis of the TeV blazar Markarian 421. The observations were collected with the Very Long Baseline Array (VLBA) at 15, 24, and 43 GHz throughout 2011 (one observation per month), both in total and in polarized intensity. We investigate the polarization structure and the magnetic field topology on parsec scale and their evolution with time. The source shows polarized emission both in the core and in the jet region, and it varies with frequency, location and time. We found the core region to be polarized by about 1% while the jet region showed an average fractional polarization of ~16%. In the jet region EVPAs were roughly orthogonal to the jet position angle for the entire observing period, implying a magnetic field parallel to the jet axis, which could be caused by velocity shear across the jet. In the core region, the EVPAs have a stable value of about 150 deg at 43 GHz, but they were more variable at lower frequencies, in particular at 15 GHz they vary in the range 110-170 deg. The higher EVPA variability at 15 GHz is due both to a variable Faraday rotation effect and to opacity. The residual variability in the intrinsic polarization angle, together with the low degree of polarization in the core region, could be explained with the presence of a blend of variable cross-polarized subcomponents within the beam. Near the VLBI radio core we found a limb-brightened structure in polarized emission and a transverse EVPA distribution, which supports the presence of a transverse velocity structure within the jet.

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## Lister, Matthew

*AGN Jet Kinematics on Parsec-Scales (I)*

Very long baseline interferometry offers the best means of investigating the complex dynamics of relativistic outflows associated with active galactic nuclei, through multi-epoch, sub-milliarcsecond, full-polarization imaging at radio wavelengths. Although targeted studies have yielded important information on the structures of individual AGN jets, the strong selection effects associated with relativistically beaming imply that general aspects of the flows can only be determined via large statistical studies. In this review I discuss recent and past results from the MOJAVE program, which has gathered multi-epoch VLBA data at 15 GHz on over 300 AGN jets for two decades. The sample is large enough to encompass a range of AGN optical class, radio luminosity and synchrotron peak frequency, and has been used to show that within a particular jet, individual bright features have a spread of apparent speed and velocity vector position angle about a characteristic value. We have found that in some cases there is a secular evolution of launch angle direction over time, indicative of evolving narrow energized channels within a wider outflow.  The majority of the jet features are superluminal and accelerating, with changes in speed more common than changes in direction. Within approximately 100 pc of the AGN, the flows are generally accelerating,

while beyond this distance the flows begin to decelerate or remain nearly constant in speed. We also find evidence for a maximum bulk flow Lorentz factor of ~50 in the pc-scale radio regime, and a trend of higher jet speeds in lower-synchrotron peaked and gamma-ray loud blazars. We discuss the implications of our findings on the blazar parent population and the fast spine/slow sheath model for TeV-detected AGN.

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## Lobanov, Andrei

*What's there in Jets: Shocks and Threads, of Cords and Frets? (I)*

The interplay between shocks and plasma instability in parsec-scale jets has enjoyed the spotlight of scientific (and artistic) debate ever since the advent of high-fidelity VLBI imaging which revealed a strikingly complex dynamics and an overwhelming wealth of internal structure in relativistic outflows in AGN. Both shocks and instability can play important roles in production of non-thermal continuum emission (possibly up to the highest energies). They can also reflect and reveal the most intricate details of the collimation and acceleration of the flow. Last but not least, they can also inspire creation of works of art and music. A historical, personally biased, and likely controversial account of these developments will be attempted here, time and audience's patience permitting.

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## Lyutikov, Maxim

*Polarization signatures of AGN jets (I)*

Parsec-scale AGN jets can be dominated by coherent large scale magnetic fields. I will describe the expected observational properties of such jets, stressing the fact that axially-symmetric jets can produce asymmetric intensity and polarization profiles. I will also discuss a model of gamma-ray flares based on the idea of mini-jet with twisted magnetic field - the model explains large smooth polarization position angle swings and yet allows for seemingly random other properties of flares, like intensity and polarization degree.

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## MacDonald, Nicholas

*Through The Looking Glass: Faraday Conversion in Turbulent Blazar Jets*

Faint levels of circular polarization (the Stokes V) have been detected in several relativistic jets (most notably 3C 279; Homan et al. 2009 ApJ, 696, 328). While typically less than a few percent, circular polarization can give us critical insight into the underlying nature of the jet plasma. Circular polarization can be produced through a

process known as Faraday conversion, in which initially linearly polarized emission produced in one region of the jet is altered by Faraday rotation as it propagates through other regions of the jet with distinct magnetic field orientations. Recently, Marscher (2014 ApJ, 780, 87) has developed the Turbulent Extreme Multi-Zone (TEMZ) model for blazar emission, in which turbulent plasma crossing a standing shock in the jet is represented by a collection of thousands of individual plasma cells, each with distinct magnetic field orientation. In order to test whether the TEMZ model can reproduce circularly polarized radiation at levels comparable to those observed in blazars, I have developed a numerical algorithm to solve the full Stokes equations of polarized radiative transfer (summarized in Jones & O'Dell 1977 ApJ, 214, 522). I have embedded this algorithm into the ray-tracing code RADMC3D (Dullemond & Dominik 2004, A&A, 421, 1075). This code is applied to ray-tracing through the 3-D TEMZ computational grid. I will present a suite of synthetic polarized emission maps that highlight the effect that thousands of distinct cells of plasma within a jet can have on the observed linear and circular polarization.

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## Marscher, Alan

*Variability of Blazars and Blazar Models over 38 Years*

Since witnessing the naming of blazars in 1978 as a postdoc, the author has devoted his scientific career to the quest of chronicling their capricious behavior, looking for patterns in that behavior, trying to explain them, and composing a song about his black-hole-crossed love affair with them. This closing talk of the conference will summarize the extent to which he and his co-conspirators, as well as others in the field, have succeeded in accomplishing these tasks. Much has been learned, some has been explained, and a number of scandals of ignorance remain.

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## Martí, José M.

*Magnetized, relativistic jets: Exploring their internal structure with numerical simulations (I)*

VLBI observations of AGN jets often point to the presence of quasi-stationary components which are associated with recollimation shocks (see, e.g. Daly & Marscher 1988). On the other hand, multi-wavelength observations of blazars suggest that gamma-ray flares are associated with the passing of superluminal components through the mm-VLBI core. The increase in particle and magnetic energy required to produce the high-energy flares can naturally be explained by identifying the mm-VLBI radio core with a recollimation shock (Marscher et al. 2008). From the observational point of view, testing these hypotheses demand to resolve the structure across the jet width with the highest angular resolutions. From the theoretical point of view, it requires to characterize the internal structure (transversal structure, internal shocks) of magnetized, relativistic jets. In the first part of the talk, we present equilibrium models

of magnetized, relativistic, axisymmetric, rotating jets propagating through a homogeneous, unmagnetized ambient medium at rest. In particular, we analyze the influence of the toroidal magnetic field (through the magnetic pressure and the magnetic tension terms) and several rotation laws (via the centrifugal force) on the structure of the equilibrium models. In the second part of the talk, these transversal equilibrium profiles are used to build initial models of overpressured, steady, superfast-magnetosonic, relativistic jets for dynamical simulations with the aim of characterizing the internal structure of relativistic magnetized jets in connection with their dominant type of energy (internal, kinetic, magnetic). The injection parameters of the models have been chosen to cover a wide region in the magnetosonic Mach number - specific internal energy plane and a wide range of magnetizations.

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## Mastichiadis, Apostolos

*Consequences of proton acceleration in blazar jets (I)*

The question whether protons contribute to the overall blazar spectrum is still an open one. Despite the fact that leptonic models can succesfully (and economically) fit the multiwavelength spectra of blazars, the hypothesis of a hadronic component has some very interesting consequences for blazar jet physics. In the present talk some of these features will be reviewed putting emphasis on the spectral and variability signatures of the leptohadronic models. Also we will address the high energy neutrino emission predicted by these models in relation to the recent IceCube detections. Finally we will discuss the overall energetics and propose particle acceleration methods that could minimize the required proton luminosity.

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## McHardy, Ian

*Multiwaveband Observations of non-blazar AGN (I)*

The most powerful jet-dominated AGN, ie blazars, have been well observed and well modelled for many years. But what about the AGN containing less powerful jets, ie LINERs, and even Seyfert galaxies? Do they behave in the same way as blazars? Are the emission mechanisms in the various wavebands the same? Here I will discuss some long timescale multiband monitoring of LINERs and Seyferts, particularly the LINER M81 and the Seyfert 1 galaxy NGC5548. I will compare their variability properties, and the relationships between the various wavebands, with those of blazars and consider whether the X-ray band could be a driver for the variability in other wavebands.

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## Meyer, Eileen

*Proper Motions of Jets on the Kiloparsec Scale: New Results from HST*

The Hubble Space Telescope recently celebrated 25 years of operation. Some of the first images of extragalactic optical jets were taken by HST in the mid-1990s; with time baselines on the order of 20 years and state-of-the-art astrometry techniques, we are now able to reach accuracies in proper-motion measurements on the order of a tenth of a miliarcsecond per year. I will present the results of a recent HST program to measure the kiloparsec-scale proper motions of eleven nearby optical jets with Hubble, the first sample of its kind. When paired with VLBI proper-motion measurements on the parsec scale, we are now able to map the full velocity profile of these jets from near the black hole to the final deceleration as the extend out into and beyond the host galaxy. We see convincing evidence that weak-flavor jets (i.e., FR Is) have a slowly increasing jet speed up to ~100 pc from the core, where superluminal components are first seen, as in M87 and 3C 264 (Meyer et al 2013, Meyer et al, 2015). I will also discuss the apparent differences in jet velocity structure with jet morphology and power, and the prospects for future observations of proper-motions on the kpc scale.

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## Miller, H. Richard

*Blazar-Like Radio Loud Narrow-Line Seyfert 1 Galaxies (I)*

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## Mizuno, Yosuke

*Magnetic dissipation in relativistic jets*

The most promising mechanisms for producing and accelerating relativistic jets, and maintaining collimated structure of relativistic jets involve magnetohydrodynamical (MHD) processes. We have investigated the magnetic dissipation mechanism in relativistic jets via 3D relativistic MHD simulations. We found that the relativistic jets involving the helical magnetic field are unstable for the current-driven kink instability, which leads to helically distorted structure in relativistic jets. We identified the regions of high current density in filamentary current sheets, indicative of magnetic reconnection, which are associated to the kink unstable regions and correlated to the converted regions of magnetic to kinetic energies of the jets. I discuss the implications of our findings for Poynting-flux dominated jets in connection with magnetic reconnection process and observed rapid variability of X-ray/TeV gamma-ray flares in blazars. I also briefly present results related recollimation shock in magnetized relativistic jets and connection to observed stationary features in relativistic jets.

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## Mueller, Cornelia

*VLBA+LMT+GBT observations indicate asymmetry in 3mm emission of Sgr A**

Located at the dynamical center of our Galaxy, the black hole candidate Sagittarius A* (Sgr A*) is an ideal target for studying the structure, emission, and dynamics close to an event horizon with high-resolution VLBI. We present the results of our 3mm observations of Sgr A* performed with the VLBA, GBT and LMT on May 23rd, 2015, at unprecedented sensitivity. Imaging and the analysis of closure quantities hint at an asymmetry in the 3mm emission. Comparing with recent results from VLBI observations at other wavelengths, we discuss this asymmetry in context of possible source intrinsic structure as well as results of interstellar scattering.

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## Nalewajko, Krzysztof

*Applying relativistic reconnection to blazar jets*

Relativistic magnetic reconnection is the most promising dissipation mechanism for highly magnetized relativistic jets in blazars, as well as in other high-energy astrophysical environments. I will discuss the insight into the mechanism of relativistic reconnection recently gained from radiative kinetic numerical plasma simulations. Then, I will discuss the application of these results to the production of non-thermal radiation in blazar jets.

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## Nishikawa, Kenichi

*Evolution of Global Relativistic Jets: Collimations and Expansion with kKHI and the Weibel Instability*

In the study of relativistic jets one of the key open questions is their interaction with the environment. Here, we study the initial evolution of both electron-proton and electron-positron relativistic jets, focusing on their lateral interaction with ambient plasma. We follow the evolution of toroidal magnetic fields generated by both the kinetic Kelvin-Helmholtz (kKH) and Mushroom instabilities (MI). For an electron-proton jet, the induced magnetic field collimates the jet and electrons are perpendicularly accelerated. As the instabilities saturate and subsequently weaken, the magnetic polarity switches from clockwise to counter-clockwise in the middle of jet. For an electron-positron jet, we find strong mixing of electrons and positrons with the ambient plasma, resulting in the creation of a bow shock. The merging of current filaments generates density inhomogeneities which initiate a forward shock. Strong jet ambient plasma mixing prevents a full development of the jet (on the scale studied), revealing evidence for both jet collimation and particle acceleration in the forming bow shock. Differences in the magnetic field structure generated by electron-proton and electron-positron jets may

contribute to the polarization properties of the observed emission in AGN jets and gamma ray bursts. The helical magnetic fields will be implements in jets and examine how they affect the evolution of jet propagation.

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## Orienti, Monica

*Flaring gamma-ray emission from high redshift blazars*

High redshift blazars are among the most powerful objects in the Universe. Although they represent a significant fraction of the extragalactic hard X-ray sky, they are not commonly detected in gamma-rays. High redshift (z>2) objects represent <10 per cent of the AGN population observed by Fermi so far, and gamma-ray flaring activity from these sources is even more uncommon. The characterization of the radio-to-gamma-ray properties of high redshift blazars represents a powerful tool for the study of the energetics of such extreme objects and the Extragalactic Background Light. In this contribution I will present results of radio to gamma-rays observations, including polarimetric VLBA, Swift and Fermi data, on PKS 0836+710, PKS 2149-306, and TXS 0536+145. The latter is the highest redshift detection of a flaring gamma-ray blazar so far. At the peaks of their respective flares these sources reached an apparent isotropic gamma-ray luminosity of about 10^50 erg/s, which is comparable with the luminosity observed from the most powerful blazars. The physical properties derived from the multi-wavelength observations of these sources are then compared with those shown by the high redshift population.

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## Ozel, Feryal

*Multiwavelength Variability in Jet and Disk Dominated GRMHD Models*

Detailed GRMHD models of nearby low-luminosity black holes combined with high-cadence ray tracing allow calculations of time-dependent spectra and predict very different multi wavelength variability properties for jet- and disk-dominated conditions. I will discuss the origins of the different broadband behavior in these cases and show how observations can be used to test the presence and properties of jets in accretion flows. I will also present results from simulations that take into account a population of non-thermal electrons with energy distributions and injection rates that are motivated by PIC simulations of magnetic reconnection. I will show that X-ray variability is a generic result of localizing non-thermal electrons to highly magnetized regions, where particles are likely to be accelerated via magnetic reconnection and accounts for the rapid timescales associated with the X-ray flares. In the case of the Galactic Center black hole Sgr A*, the qualitative nature of this variability is consistent with observations, producing X-ray flares that are always coincident with IR flares, but not vice versa.

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## Pacciani, Luigi

*High Energy flares of FSRQs: the connection of flaring states with the accretion disk luminosity*

High-Energy gamma-ray flares (E>10 GeV) of Flat Spectrum Radio Quasars (FSRQ) give us strong constraints on jet-physics, and on the surrounding-medium. We performed the first study of these flares, examining FERMI-LAT archival-data, and triggering 40 ToO-observations from near-ir to TeV (e.g., for PKS 1441+25), at the occurrence of new flares. We identified about 270 gamma-ray flares. Among these, we investigated peculiar and short-flares of 3C 454.3 and CTA 102, showing remarkably hard gamma-ray spectra. We discuss here the broad-band spectra of 13 High Energy flares, and their variability-timescales in terms of injection and cooling of energetic-particles, arguing that these flares originate at parsec distance from the Supermassive Black-Hole (distant scenario), possibly powered by magnetic-reconnections or turbulence in the flow. For the whole sample of 270 flares, we will show spectral and temporal properties. Even though several engines proposed for the "distant scenario" does not require to be connected with accretion disk, we will show and discuss that jet luminosities and disks correlate not only on years averaged time-scales, but also during High-Energy gamma-ray flares (time-resolved within this investigation with time-scale of the order of 10 days or less).

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## Padovani, Paolo

*Extreme blazars as counterparts of IceCube neutrinos*

We make the case for extreme blazars, i.e. strong, very high energy gamma-ray sources of the HBL type, to be the counterparts of at least some of the IceCube neutrinos. Our results are based on: 1. a joint positional and energetic diagnostic that makes use of high-energy source catalogues; 2. a theoretical modelling of their spectral energy distributions within a lepto-hadronic scenario; 3. a detailed calculation of the neutrino astrophysical background from the whole BL Lac class based on an extrapolation of our findings from individual sources through sophisticated Monte Carlo simulations, which reproduce all the main properties of these sources in the radio, X-ray, and gamma-ray bands. Our first approach gives a positive correlation between extreme blazars and IceCube neutrinos, which is significant at the 0.4% level, with these sources explaining ~ 10 - 20% of the IceCube signal.

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## Paneque, David

*Mrk421 and Mrk501 as high-energy physics laboratories to study the nature of blazars (I)*

The blazars Mrk421 and Mrk501 are among the brightest keV and TeV sources in the sky, and among the few sources whose (radio to VHE gamma-rays) Spectral Energy Distributions (SEDs) can be characterized by current instruments by means of relatively

short observations (minutes to hours). Consequently, Mrk421 and Mrk501 can be studied with a larger degree of accuracy than most of the other blazars whose emissions are weaker or are located farther away. Since 2008, there has been an unprecedentedly long and dense monitoring of the broadband emission from these two archetypical TeV blazars, involving the participation of Fermi, MAGIC, VERITAS, FACT, F-GAMMA, Swift, RXTE, NuSTAR, GASP-WEBT, VLBA, and other collaborations/groups and instruments which have been providing the most detailed temporal and energy coverage on these sources to date. In the conference I will report some highlight results from these campaigns that have been recently published. Both Mrk421 and Mrk501 have shown a large complexity in the temporal evolution of their broadband SEDs, with the presence of different flavors of flaring activity. Despite some differences in their variability patterns, there are also a number of similarities that support a broadband emission dominated by leptonic scenarios, as well as indications for in situ electron acceleration in multiple compact regions.

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## Pearson, Timothy

*Blazar Jets: insights from Radio and Gamma-ray Light Curves*

The Fermi Gamma-Ray Space Telescope provides a unique opportunity for studying nature's high energy accelerators and the relativistic jets in blazars and microquasars. More than 1500 blazars have have been detected by Fermi, and the gamma-ray flares can often be associated with radio flares. Since 2008, we have been monitoring the flux density of AGN, including most of the northern Fermi blazars, twice weekly at 15 GHz using the Owens Valley Radio Observatory 40m telescope. The program now includes more than 1800 sources, and has recently been augmented with linear polarization measurements. Our monitoring program has sufficient sources, cadence, and sensitivity to enable detailed statistical studies of the variability of different classes of blazars (e.g, flat-spectrum radio quasars and BL Lac objects; LSP and HSP blazars). Although the gamma-ray and radio light curves have very different characteristics, cross-correlation using rigorous statistical methods shows significant correlations in some objects. In all such cases the gamma-ray variations precede the radio variations, suggesting that the gamma-ray emission originates upstream of the radio emission. Radio, optical, and gamma-ray light curves, including radio and optical polarization, can now be compared with state-of-the art magnetohydrodynamic simulations to test and refine theoretical models of black holes, accretion disks, and relativistic jets.

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## Psaltis, Dimitrios

*Probing the Jet-Accretion Flow Connection with the Event Horizon Telescope (I)*

The Event Horizon Telescope will offer near horizon-scale resolution for imaging the inner accretion flows of many accreting supermassive black holes that harbor powerful jets. This will allow us to identify not only the location of jet launching but also the

physical processes that lead to jet emission in these settings. I will discuss the results of recent GRMHD simulations of accretion flows that help us develop new imaging techniques that will exploit the unprecedented capabilities of the Event Horizon Telescope in probing the disk-jet connection around supermassive black holes.

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## Pushkarev, Alexander

*Shapes of AGN jets on scales from parsecs to hectoparsecs*

We used 15 GHz VLBA observations of 373 sources having at least 5 epochs within a 20-yr time interval 1994–2015 from the MOJAVE program and/or its precursor, the 2 cm VLBA Survey. For each source we produced a corresponding stacked image averaging all available epochs for a better reconstruction of the cross section of the flow. We have analyzed jet profiles transverse to the local jet ridge line and derived both apparent and intrinsic opening angles of the parsec-scale outflows. We compared the jet opening angles between sources detected and non-detected by the Fermi Large Area Telescope (LAT) during the first 48 months of operation and derived probability functions of the corresponding viewing angle distributions. We analyzed transverse shapes of the parsec-scale outflows. We also used 1.4 GHz single-epoch VLBA observations of 135 MOJAVE-1 sources to probe larger, hectorapsec scales of the outflows.

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## Rani, Bindu

*Exploring the magnetic field configuration close to central engines using GMVA*

The high radio frequency polarization imaging of non-thermal emission from AGN is a direct way to probe the magnetic field strength and structure in the immediate vicinity of SMBHs and is crucial in testing the jet-launching scenario. To explore the the magnetic field configuration at the base of jets in blazars, I took advantage of the full polarization capabilities of the GMVA (Global Millimeter VLBI Array). With an angular resolution of ~50μas at 86 GHz, one could reach scales down to ~900 Rs (for a 10^8 solar mass black hole). On sub-mas scales the core and central jet of BL Lac is polarized with the EVPA being aligned well with jet in the North-South jet direction. This suggests a well ordered magnetic field, with its main component being perpendicular to the jet axis. Such a field configuration is consistent with a helical magnetic field in the jet. We also note the great morphological similarity between the 7mm/3mm VLBI images and the space-VLBI image obtained at 22 GHz with the RadioAstron satellite at very similar angular resolution. In this talk, I will show the results of our study on BL Lac.

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## Rioja, Maria J.

*The Power of Simultaneous Multi-Frequency Observations for mm-VLBI and Astrometry (I)*

Simultaneous observations at multiple frequency bands hold the potential to overcome the fundamental limitations imposed by the atmospheric effects in mm-VLBI observations. These place a severe limit in the sensitivity achievable and prevent the use of phase referencing and astrometric measurements in the high frequency regime. The development of new calibration techniques opens up exciting opportunities and widens the applicability to new fields of research, which require high precision astrometry at mm-wavelengths. I will present the theoretical justification of the approaches we have developped, Source Frequency Phase Referencing, and Multi Frequency Phase Referencing, along with experimental demonstrations from our recent work applied to studies of AGNs.

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## Savolainen, Tuomas

*Space-VLBI observations of nearby radio galaxies with RadioAstron (I)*

RadioAstron space-VLBI program has made cm-wavelength interferometric observations possible at an unprecedented angular resolution, down to tens of microarcseconds level. This angular resolution translates to a spatial resolution of only a few to a few hundreds of Schwarzschild radii at the distance of the nearby radio galaxies allowing one to probe the jet acceleration and collimation zone and offering a unique view of the internal jet structure. The RadioAstron Nearby AGN Key Science Program has carried out near-perigee space-VLBI imaging of nearby radio galaxies - M87, Centaurus A and 3C84. Fringes on 3C84 and M87 were successfully detected on space-baselines at all the observing frequencies, and also high-quality imaging turned out to be possible. We will present an update on the results obtained in this program so far.

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## Sikora, Marek

*Powers and magnetization of blazar jets (I)*

Powers and magnetization of blazar jets ABSTRACT: Constraints imposed by observations of blazars on energetics and magnetization of quasar jets are reviewed and confronted with theoretical expectations. Discussion is focused on such issues as jet production efficiency, jet acceleration and collimation, and particle acceleration mechanisms.

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## Smith, Paul

*Sharp Polarimetric Eyes: More Trees than Forest? (I)*

The Fermi Gamma-ray Space Telescope has focused the intensive multi-wavelength and multi-national observational effort on blazars since its launch almost eight years ago. Part of this effort involves the systematic monitoring of the highly variable polarization of the continuum emission from these objects. These observations are valuable in that they provide direct information on the degree of ordering and orientation on the sky of the magnetic field within the non-thermal emission region(s). Unfortunately, it is not yet possible to measure the polarization of the inverse-Compton continuum, only that of the lower-energy synchrotron emission. The inability to directly compare the polarization of the two dominant continuum sources in blazars is a drawback and leads to more ambiguities in determining their relative locations. There are many compelling examples of strong connections between gamma-ray, X-ray, optical/IR, and radio behavior in blazars that suggest the same region produces much of the observed emission at all wavelengths at least some of the time. However, the wealth of polarization behavior seen relative to flux changes invariably results in a complex situation that is difficult to interpret and model. The long-term monitoring program at Steward Observatory is one of several ongoing efforts during the Fermi mission to obtain accurate optical polarimetry of gamma-ray-bright blazars with the goal of gaining important insights into the jet structure and physics of these objects. Data from this program are available to all researchers as soon as reductions are completed. I briefly detail the current status and progress of the program and the data products available. Although the wide variety of polarization behavior in blazars adds another layer of complexity to an already difficult problem, I summarize several important conclusions that can be drawn from the polarization information gathered during the Fermi era.

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## Stawarz, Lukasz

*Constraining Magnetic Field Structure and Particle Acceleration Processes in Blazar Jets (I)*

In this talk I will present our recent analysis of broad-band spectra, variability, and polarization properties of relativistic jets in blazar sources, including (i) Faraday rotation measure gradients, (ii) multi-wavelength power spectra in different frequency ranges, and (iii) radio spectral indices of self-absorbed segments of the outflows. I will discuss the resulting constraints on the jet magnetic field structure, jet magnetisation and content, and the energy dissipation processes involved in acceleration jet particles to ultra-relativistic energies.

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## Takamoto, Makoto

*Relativistic Turbulent Reconnection and Application to Jet Acceleration*

The energy conversion from magnetic field energy into bulk kinetic energy is one of the most important problems for many high energy astrophysical phenomena, in particular, relativistic jets. In this presentation, we report on our recent findings of the enhancement of the magnetic reconnection rate by turbulent processes in a Poynting-dominated plasma. We performed 3-dimensional relativistic resistive magnetohydrodynamics simulations, and found that reconnection rate becomes very fast and independent of the plasma resistivity due to turbulent effects. However, we also found that compressible turbulence effects modify the turbulent reconnection rate predicted in non-relativistic incompressible plasmas. We also discuss the relativistic effects and possible astrophysical applications.

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## Valtaoja, Esko

*A lifetime of blazars (Opening talk)*

It is now 54 years since the momentous discovery of the redshift of 3C 273 by Maarten Schmidt, and 38 years since Edward Spiegel gave the name *blazars* to a subclass of active galactic nuclei. Amazingly, at least two of our conference participants started their scientific careers before we became aware of the existence of active galactic nuclei, and even that new kid on the block, Alan Marscher, wrote his first papers before we had blazars. Lifetimes of science, lifetimes of blazars, indeed.
Science is a very *human* endeavour, although much of its human workings remain hidden from the outsiders. Far from sitting alone in our ivory towers, we scientists live in a worldwide network of acquaintances, competitors, drinking buddies, friends and sometimes even lovers, without whom we could achieve very little. It was no accident that the WWW started as scientists' tool for communication.
I will take a lopsided and not too serious look at our blazar history, doing some data archeology with the NASA ADS to see how our lives evolve with the evolution of blazar research (or vice versa). Some new scientific results will be presented, including an observational proof of Goethe's celebrated hypothesis from 1832.

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## Wagner, Stefan

*A Gamma-Ray View on Multi-Wavelength Studies of Blazars (I)*

HE and VHE observations extend the broad-band coverage of Blazar studies beyond 10^27 Hz and complement lower frequency studies in many ways. Correlations between high- and low-energy variations in individual objects and corresponding high- and low-

energy properties within the population of Blazars are ubiquitous but display significant scatter. Differences are likely to provide insight into the spatial structure of the emitting volumes at different frequencies. Multifrequency studies hence provide clues on Blazar structure beyond the resolving power of direct imaging. Particular emphasis is placed on rapid variability at high gamma-ray energies which implies indirect evidence for the most compact structure inferred in Blazars so far.

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## Walker, R. Craig

*Observations of the Structure and Dynamics of the Inner M87 Jet (I)*

M87 is one of the best sources in which to study a jet at high resolution in gravitational units. With a 3-6 x 10^9 solar mass black hole and a relatively small distance of 16.7 Mpc, the angular size of the black hole is second only to SgrA*, which does not have a strong jet. The jet structure is edge brightened with a wide opening angle base and a weak counterjet. We have roughly annual observations for 17 years plus intensive monitoring at three week and five day intervals made with the VLBA at 43 GHz. The inner jet shows very complex dynamics, with apparent motions both along and across the jet. Velocities from zero to over 2c are seen, with acceleration likely over the first milli-arcsecond. This is consistent with the sidedness ratio seen with the counterjet. Details of the structure and dynamics will be discussed. Also, a detection of relative motion of the cores of M87 and M84 will be shown.

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## Wardle, John (I)

*Magnetic Fields and Polarization in Blazar jets: progress since 2013*

This review will look at progress made since the Granada jets meeting in 2013. Particularly exciting is the thrust towards millimeter and (soon) sub-millimeter wavelengths with the GMVA and the EHT. With an Earth-sized array, resolution approaches a few gravitational radii on Sgr A* and M87. For more distant blazars, we can see the beginning of the jets at unprecedented resolution. The Magnetically Arrested Disk (MAD) model provides good reason to believe that jets are launched by strong magnetic fields at the central black hole/accretion disk system. It follows that polarization observations will be essential for elucidating the precise physics of this process. We include a discussion of how best to make images (in both total intensity and polarization) of the emission around SMBHs with sparse arrays, making use of the most robust measurable quantities. Today, 3D GRMHD simulations that would be unthinkable not so long ago are now progressing as fast as the observations in a highly productive symbiosis. The comparison between theory and observation will be significantly enhanced if the theory can put mass loading and particle acceleration on a more certain basis, and if the observations can achieve higher resolution (i.e. are made at shorter wavelengths) to better match the simulations.

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## Webb, James

*Multifrequency Blazar Microvariability as a Tool to Investigate Relativistic Jet Flow (I)*

For the past 10 years we have been studying microvariability in a sample of Blazars. The intermittency, the stochastic nature, and the similar profile shapes seen in microvariations at different times and in different objects have led us to a possible model to explain the observed microvariations. The model is based on a strong shock propagating down a relativistic jet and encountering turbulence which causes density or magnetic field enhancements. We use the theory of Kirk, Reiger, and Mastichiadis (1998) to describe the pulse of synchrotron emission emanating from individual turbulent cells energized by the shock. By fitting these "pulses" to microvariability observations, we obtain excellent fits to actual microvariations. The model predicts that the spectral index changes as a function of pulse duration. This effect should be observable in multi-frequency microvariability data. We present the theoretical model, model fits of our microvariability light curves, and preliminary multi-frequency microvariability observations that support this model. A further test that has yet to be carried out involves observing polarization changes in different pulses.

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## Wehrle, Ann

*Multi-wavelength studies of blazars BL Lac and 3C454.3 (I)*

We use multiwavelength observations of blazars to measure time lags and correlations between bands, and to study the changing shapes of the spectral energy distributions. When a blazar flares, a strong injection of energy in the form of particles occurs in the relativistic jet which causes various parts of the spectral energy distribution to rise. I will discuss recent multiwavelength campaigns on archetypal blazars such as 3C454.3 and BL Lac involving Herschel, Swift, NuSTAR, Fermi, the Submillimeter Array, CARMA, and the VLBA. From these observations, we form a physical picture of the structure, kinematics and evolution of the jet within a few parsecs of the central supermassive black hole.

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## POSTERS

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### Abraham, Zulema

*Millimeter Multiwavelength Observations of Blazars with the LLAMA Radiotelescope.*

Simultaneous multiwavelength observations are fundamental for the understanding of the emission mechanism of blazars. Millimeter and submillimeter emission can be observed with few radiotelescopes around the world, and campaigns of simultaneous observations are generally not long enough to guarantee useful correlation between the different frequencies. In this context, I will describe the LLAMA radiotelescope, to be installed in the Argentinian Andes, at 4800m altitude and 150 km from the ALMA site. With a 12m Cassegrain dish and two Nasmyth cabins, it will operate within six of the ALMA bands, from 30 to 700 GHz. Three receivers will be installed in each of two cryostats, allowing rapid changes between frequencies and in the future, even simultaneous observations at several frequencies. This configuration will allow almost simultaneous observations of blazars, when used as single dish. The radiotelescope will also have VLBI capability, and its privileged position will allow its participation in the EHT, as well as in other mm wave VLBI experiments.

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### Acosta Pulido, Jose A.

*A new statistical approach to the optical spectral variability in a sample of Gamma-Bright Blazars.*

We present a statistical study based on optical spectroscopic observations of a list of gamma-ray bright blazars. We have used the observations obtained as part of the ground-based observational support program to the Fermi mission conducted at Steward Observatory (Univ. of Arizona). Spectra of about 35 targets have been obtained with an almost weekly cadence. We retrieved observations from the end of 2008 to beginning of 2016, i.e. about 7.5 years. We have obtained synthetic photometry and produced colour-magnitude diagrams which show different trends associated to the object classes: generally BL-Lacs tend to become bluer when brighter, FSRQs redder when brighter, although several objects exhibit different trends depending on the brightness. We have also applied a pattern recognition algorithm to obtain the minimum number of physical components which can explain the variability of the optical spectrum.

We have used NMF (Non- Negative Matrix Factorization) instead of PCA (Principal Component Analysis) to avoid un-realistic negative components. For most targets we found that two meta-components are enough to explain the observed spectral variability. The spectral shape of these components will be presented and their association to plausible physical emission mechanisms (synchrotron, accretion disk, inverse- Compton, stellar population, etc) will be discussed. The relative contribution of each component is also studied in relation to colour changes and variability observed in other frequency ranges.

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## Agarwal, Aditi

*Frequency-dependent core shifts and parameter estimation in blazars*

We study the core shift effect in the parsec-scale jet of blazars using the 4.8-36.8 GHz radio light curves obtained from four decades of continuous monitoring. From a piecewise Gaussian fit to each flare, time lags between the observation frequencies and spectral indices (α) based on peak amplitudes (A) are determined. Index k is calculated and found to be ∼ 1, indicating equipartition between the magnetic field energy density and the particle energy density. A mean magnetic field strength at 1 pc (B1) and at the core (Bcore) are inferred which are found to be consistent with previous estimates. The measure of core position offset is also performed by averaging over all frequency pairs. Based on the statistical trend shown by the measured core radius as a function of frequency, we infer that the synchrotron opacity model may not be valid for all cases. A Fourier periodogram analysis yields power-law slopes in the range 1.6 to 3.5 describing the power spectral density shape and gives bend timescales. This result, and both positive and negative spectral indices, indicate that the flares originate from multiple shocks in a small region. Important objectives met in our study include: the demonstration of the computational efficiency and statistical basis of the piecewise Gaussian fit; consistency with previously reported results; evidence for the core shift dependence on observation frequency and its utility in jet diagnostics in the region close to the resolving limit of very long baseline interferometry observations.

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## An, Hongjun

*SEDs of three high-redshift BL Lac objects and EBL constraints*

We present results of data analyses and SED modeling of three high-redshift BL Lac objects 3FGL J0022.1-1855 (z=0.689), 3FGL J0630.9-2406 (z>1.239), and 3FGL J0811.2-7529 (z=0.774). We have a set of nearly contemporaneous optical to X-ray observations (GROND, XMM-Newton, NuSTAR) and further improved the SED's sampling with archival infrared observations, optical spectra, and historical Fermi-LAT data integrated over 6.5-yr. The well-sampled broadband SEDs of these sources allow sensitive modeling with the one-zone synchro-Compton model of Boettcher et al. (1997).

The results are interesting in that the highest-z source can be used for constraining EBL absorption models and in that emission properties of unusual, high-power BL Lacs can be inferred. We discuss possible implications for the BL Lac population and the blazar sequence.

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## Bachev, Rumen

*The extremes in intra-night blazar variability: the S4 0954+65 case*

We present results of optical observations of an extremely violently variable blazar S4 0954+65 on intra-night time scales. The object showed flux changes of up to 100% within a few hours. Possible time delays between optical bands are searched for and the results are discussed in terms of existing models of blazar variability.

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## Banasiński, Piotr

*Dynamical Inhomogeneous Model for High Energy Emission from blazars*

Based on gamma-ray emission from blazars, two states can be identified - quiescent state and active state. However, the blazar emission in long lasting quiescent state and violent outburst is difficult to explain with a single process. In our work, we present dynamical emission model of blazar jet in which radiation in the low emission state comes from the extended jet and the outbursts are produced by the magnetic reconnection process in the vicinity of jet base. The results of numerical calculations are compared with observations of the nearby blazars, in both, the quiescent and the active states.

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## Becerra Gonzalez, Josefa

*Physical implications of the most extreme X-ray flaring activity of the high-peaked BL Lac Mrk 501 from a detailed multi-wavelength study*

The high-frequency-peaked BL Lac object Markarian 501 is a very high energy (VHE, E>100 GeV) emitter located in our extragalactic neighborhood (z=0.034). The source can be detected in the VHE band during low state, what makes this target an ideal source for long-term multi- wavelength studies covering the entire electromagnetic spectrum. During a multi-wavelength campaign in 2014, the source showed the highest X-ray activity observed by Swift-XRT during the last decade. The source displayed very hard spectra at X-rays and gamma-ray energies with variability on day timescales. The temporal evolution of the broadband SED, studied during 2 weeks on a day-by-day basis,

suggests the existence of ultra-energetic electron energy distributions contributing to the broadband emission of Mrk501. In the conference I will report about this unprecedented flaring event and its physical implications in the multi-wavelength context.

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**Bednarek, Wlodek**

*Gamma-rays from collisions of compact objects with intermediate scale jets in AGNs*

Massive blakc holes are immersed in galactic bulges and nuclear stellar clusters which are also surrounded by spherical halos composed of globular clusters. These compact objects should collide from time to time with the jet disturbing its plasma flow. We calculate the synchrotron and the IC gamma-ray spectra produced by elelctrons accelerated in such collision regions within the jet. The model is applied to the non-thermal emission from the jet in the nearby radio galaxy Cen A from which steady emission with a complex spectrum has been recently reported.

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## Beuchert, Tobias

*Probing the parsec-scale jet of the radio galaxy 3C111 with radio polarimetry using Effelsberg and MOJAVE*

We present a dedicated polarimetry study of the radio galaxy 3C 111 based on five years of radio single-dish observations with the Effelsberg 100-m telescope at 10 GHz as part of the F-GAMMA programme and MOJAVE VLBI observations at 15 GHz between early 2007 and mid 2012. The imaging data reveal a number of separate significantly polarized regions that we relate with shocks propagating down the jet, which locally compress an underlying, tangled magnetic field increasing its uniformity. These regions show not only rapid changes in polarized flux but also a complex and variable pattern of electric vectors displaying an EVPA swing of more than 180 degrees in about 4 years. The smooth evolution of the EVPAs, their transversely resolved structure as well as a study of the brightness temperature evolution allow us to interpret them as indications for a shock-shock interaction with a conical re-collimation shock. We additionally use quasi-simultaneous Effelsberg data at 10 GHz to probe the hidden complex pc-scale jet dynamics with single-dish studies.

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## Borisov, Sergei

*Observations of TeV gamma-rays from BL Lacs and its connection with activity at low energies*

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The long term SHALON observations yielded data on extragalactic sources of different type at energy range of 800GeV - 100 TeV. During the period 1992 - 2016, SHALON has been used for observations of several AGNs of the "blazar" class. We present results of observations of known BL Lac objects Mkn 421, Mkn 501, Mkn 180 as well as Radio galaxy 3c 382. Also, the observation data on BL Lac type object OJ 287 (detected by SHALON) including the high level flux period of 2010 y. are summarized in this presentation. The observation results are presented with integral spectra, images and spectral energy distributions for each of sources at energies above 800 GeV. All data from SHALON observations are compared with ones from experiments at high and very high energies. A number of variability periods in different wavelengths including VHE gamma-rays were found. For example, the last flaring state of Mkn 501 at the very high energies was detected in the SHALON observational period between March and June 2009. This increase is correlated with the flaring activity at lower energy range in observations of Fermi LAT and Whipple, VERITAS, MAGIC.

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## Bruni, Gabriele

*Imaging AGN at record angular resolution: space-VLBI in the RadioAstron hera*

RadioAstron is the first observatory in history of astronomy able to provide space-baselines up to 25 Earth-diameters, and in full polarization. A new version of the DiFX software correlator has been developed to handle a spaceborne antenna, and is nowadays in use at the MPIfR correlator in Bonn. I will review the technological challenges and progresses that marked the steps towards the highest angular resolution image ever, obtained in the framework of the RadioAstron AGN-polarization KSP.

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## C. S., Stalin

*Narrow Line Seyfert 1 galaxies: A new class of gamma-ray emitting AGN*

Prior to the year 2008, only two classes of gamma-ray emitting AGN are known, namely blazars and radio-galaxies. The launch of the Fermi Gamma-ray Space Telescope in late 2008, has led to the discovery of gamma-ray emission from a new class of objects, namely, the Narrow Line Seyfert 1 (NLSy1) galaxies. As of now, less than a dozen gamma-ray emitting NLSy1 galaxies are detected with high significance by Fermi. This clearly demonstrates that relativistic jets are present in these sources. However, it is generally thought that NLSy1 galaxies are hosted by spiral galaxies and as gamma-ray ray emission is detected in them, it is clear now, spiral galaxies can also host relativistic jets which is against the "Elliptical – Jet paradigm". We have carried out a systematic study of these gamma-ray NLSy1 galaxies using data in the optical from the Himalayan Chandra Telescope, UV from Swift UVOT, X-rays from Swift-XRT, Swift-BAT and gamma-rays from Fermi. It is found that these sources have properties similar to the Flat Spectrum Radio Quasar (FSRQ) class of AGN. For, one gamma-ray emitting NLSy1 galaxy

1H 0323+342, we find that it shows both the properties of a radio-quiet Seyfert galaxy and a FSRQ. Further details of these results will be presented.

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## Castro-Tirado, Alberto

*The powerfulness of BOOTES Network of Robotic Telescopes for AGN monitoring*

The BOOTES network of robotic telescopes has deployed in late 2015 its last observing station (BOOTES-5) in Mexico, thus completing the Northern Hemisphere Network. We will show the capabilities of the BOOTES instruments for long-term AGN monitoring campaigns.

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## Dai, Yan

*Optical Behavior of S5 0716+714 from 2012 to 2014*

We monitored Blazar S5 0716+714 in the optical B, V, R, and I bands with 2.16m, 60cm, 80cm, and 85cm telescopes of NAOC at Xinglong Observation. Especially in 2014, we used three telescopes with four different bands to observe the target that improve time resolution substantially. We studied its optical flux and spectral variations and searched for the inter-band time lags. A strong bluer- when-brighter chromatism was found on the intra-night timescale.

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## Einecke, Sabrina

*Search for high-confidence blazar candidates and their MWL counterparts in the Fermi-LAT catalog using machine learning*

The Large Area Telescope (LAT) on board the Fermi satellite conducted the deepest all-sky survey in gamma-rays so far. Despite outstanding achievements in assigning source types, 1010 sources in the Third Fermi-LAT Source Catalog (3FGL) remain without plausible associations, and 573 sources are associated to active galaxies of uncertain type. Assigning blazar classes to unassociated and uncertain sources, and linking counterparts to the unassociated ones, will refine tremendously our knowledge of the population of gamma-ray emitting objects. The application of machine learning algorithms has become an integral part of exploring astrophysical data. Previous machine learning strategies to assign source types were based solely on properties extracted from gamma-ray observations. The extension to multiwavelength information, especially the relation between properties extracted from different parts of the energy spectrum, provides additional source type- specific characteristics for better

classification. At the same time, it offers the possibility to determine the most likely corresponding counterpart. The source localization accuracy of Fermi measurements, given by the 95% confidence region, is in the order of several arcminutes. Typically several hundred possible counterparts are located within this region, making the association ambiguous. To figure out the most likely counterpart, the associated sample is used to train machine learning classification algorithms. For any particular 3FGL source, all possible combinations with measurements of one additional energy range are considered, e.g. from the Wide-Field Infrared Survey Explorer (WISE) source catalog, the Sydney University Molongo Sky Survey (SUMSS) radio catalog, or the Swift X-ray Point Source (1SXPS) catalog. By merging the most probable candidates of each of those studies, the power of multiwavelength strategies is exploited and conclusions with even higher confidence concerning blazar counterpart candidates are drawn. In this talk, the statistical model and its validation to estimate the performance is described. Finally, results of the application of this novel wavelength-dependent approach are presented.

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## Fan, Junhui

*Optical Variability of Blazars*

In this work, we'll present the optical light curve of AO 0235+164 observed with the 0.70-m telescope at Abstumani Observatory, Georgia and periodicity analysis methods are performed to the light curve that combining our observations and the historic ones. Some signs of periodicity are found.

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*Beaming Effects for Fermi Blazars*

We will present the spectral energy distributions (SEDs) for about 1400 Fermi blazars. Their synchrotron peak frequencies, peak luminosities, bolometric luminosities, and effective spectral indexes are calculated from the available observations. Some statistical analyses for the whole sample and the subclasses of blazars are investigated using beaming effect.

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## Frey, Sándor

*Precessing jet in the high-redshift blazar J0017+8135*

The prominent flat-spectrum radio quasar J0017+8135 (S5 0014+81) at z=3.366 is one of the most luminous active galactic nuclei (AGN) known. Its milliarcsecond-scale radio jet structure has been studied with very long baseline interferometry (VLBI) since the 1980's. The quasar was selected as one of the original defining objects of the International Celestial Reference Frame (ICRF), but left out from its current second realization (ICRF2) because of systematic long-term positional variations. Here we analyse archival X- and S-band VLBI imaging data collected at nearly 100 different

epochs during more than 20 years, to obtain information about the kinematics of jet components. Because of the cosmological time dilation, extensive VLBI monitoring data are essential to reveal changes in the jet structure of high-redshift AGN. These changes appear a factor of (1+z) slower than in the rest frame of the source. In the case of J0017+8135, the data can be described with a simple kinematic model of jet precession with a 12-year periodicity in the observer's frame.

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## Garrigoux, Tania

*Modeling polarized emission from relativistic outflows*

The X-ray and gamma-ray emissions from highly energetic astrophysical sources such as Gamma-Ray Bursts and Active Galactic Nuclei, are believed to be produced primarily by two mechanisms: synchrotron radiation (SR) and inverse Compton scattering (ICS). The study of the polarization of the emissions is an important tool in the analysis of these mechanisms. We investigate the polarization of photons produced by ICS of relativistic electrons on various target photon fields, including the CMB. We present polarization results over the whole energy spectrum, including the trans-relativistic regime, considering initially unpolarized photons and electrons in any spectral distribution.

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## Gaur, Haritma

*Variability and Polarization Studies of BL Lacertae*

We present the results of photometric (V band) and polarimetric observations of the blazar BL Lac during 2008-2010 using TRISPEC attached to the KANATA 1.5 m telescope in Japan. The V band flux strongly anticorrelates with the degree of polarization during the first of two observing seasons but not during the second. The direction of the electric vector, however, remained roughly constant during all of our observations. We computed models involving helical jet structures and single transverse shocks in jets and show that they might be able to agree with the anticorrelations between flux and fractional polarization. Also, we extensively observed this source in optical and radio bands during an active phase in the period 2010-2013 when the source showed several prominent outbursts. We will present results of the possible correlations and time lags between the optical and radio band flux variations using multi-frequency data to learn about the mechanisms producing variability.

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## Glawion, Dorit

*Multi-wavelength observations of IC 310 following an extreme gamma-ray outburst*

IC 310, a one-sided radio galaxy in the Perseus Cluster, has repeatedly shown large-amplitude and short-time-scale variability at TeV photon energies. The observed variability and hard spectrum of the minute-scale flare in November 2012 cannot be explained by shock acceleration in the jet, but instead by highly anisotropic particle beams at the base of the jet. The particle beams fire electromagnetic cascades, loading the jet with electrons and positrons. After passing through shocks further down the jet, the injected particles should lead to flux enhancements at radio frequencies. In search of this afterglow, we carried out multi-wavelength follow-up observations, including the European VLBI Network and MOJAVE. Here, we report the first results of this campaign.

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## Goyal, Arti

*Flux variability of classical BL Lac object PKS 0735+178*

The power spectral density (PSD) spectra of flux variability of blazars, $P(f) = A f^{-\beta}$, where A is the normalization and $\beta$ is the slope, indicate that the variability is generated by the underlying {\it stochastic} processes (i.e., $\beta \simeq 1-3$, characteristic of flicker/red noise). Study of power-law slopes, normalization or characteristic timescales (if any), in the PSD is important for constraining the physics of emission and energy dissipation processes in the blazar jets. In this talk, I will present the results of PSD analysis of lightcurves at GeV (using {\it Fermi}- LAT), optical (R-band) and radio (GHz band from UMRAO and OVRO programmes), covering time periods ranging from few decades to sub-hours, for the BL Lac object PKS 0735+178. The novelty of this study is that at optical frequenices, by combining long-term and densely sampled intra-night lightcurves, we constructed the PSD for time periods ranging from 23 years down to sub-hour timescales. The main results from our analysis are : (1) nature of processes generating flux variability at optical/radio frequencies is different from those at GeV freqeuncies ($\beta \sim $ 2 and 1, respectively); this could imply, that $\gamma-$ray variability, unlike the Synchrotron (radio- to-optical) one, is generated by a superposition of two stochastic processes with different relaxation timescales, (2) the main driver behind the optical variability is same on years, months, days, and hours timescales ($\beta \sim 2$), which argues against the scenario where different drivers behind the long-term flux changes and intra-night flux changes are considered, such as internal shocks due to the jet bulk velocity fluctuation (long-term flux changes) versus small-scale magnetic reconnection events taking place at the jet base (intra-night flux changes). Implications of these results are discussed in the context of blazar emission models.

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## Gupta, Alok

*Flux and Spectral Variability of Blazars with XMM-Newton*

In the present talk, I will discuss our recent results based on multi-band observations of

blazars with XMM-Newton in optical, UV and X-ray bands. I will report the results of flux and spectral variability of diverse timescales and their possible emission mechanism.

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## Hervet, Olivier

*The relevance of a blazar kinematical classification*

The blazar jet kinematics observed at very hight resolution in radio VLBI is surprising. The wide majority of these jets show several radio surdensities (knots) but behave in various ways. Some of them show quasi-stationary knots, some of them present relativistic velocities, and others show an hybridization between these two cases. The idea tested here is to classify a large sample of blazar following their VLBI kinematic features in order to understand what could be the origin of these differences. A notable result is that the VLBI kinematical behaviour is linked to the blazar spetral properties, classified as HBLs, IBLs, LBLs and FSRQs; but also linked to the large scale radio jet luminosities. It will be shown how a scenario of multiple recollimation shocks in structured jets is fully appropriated to describe the characteristics of these kinematic classes.

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## HU, Shao Ming

*Statistical Analysis on Temporal Properties of BL Lacertae*

A comprehensive temporal analysis has been performed on optical light curves of BL Lacertae in B, V, R and I bands. The light curves were denoised by Gaussian smoothing and decomposed into individual flares using an exponential profile. Symmetry, duration time, peak flux and energy output of flares were measured and the distributions are presented. Most optical flares on short-term scales are highly symmetric. The distributions of flare durations, peak fluxes are not random but consistent with a gamma distribution or lognormal distribution. A positive correlation is detected between flare durations and peak fluxes. Results presented here can serve as constraints on physical models attempting to interpreting blazar variations.

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## Inoue, Yoshiyuki

*Baryon Loading Efficiency and Particle Acceleration Efficiency of Relativistic Jets: Cases For Low Luminosity BL Lacs*

AGN jets are known as the most energetic particle accelerators in the universe. However,

the baryon mass loading efficiency onto the jets from the accretion flows and the particle acceleration efficiency in the jets have been veiled in mystery. With the latest data sets, we perform multi- wavelength spectral analysis of quiescent spectra of 13 TeV gamma-ray detected HBLs following one-zone SSC model. We determine the minimum, cooling break, and maximum electron Lorentz factors following the diffusive shock acceleration (DSA) theory. We find that HBLs have P_B/P_e~0.025 where P_B and P_e is the Poynting and electron power, respectively. Using the black hole mass measurements, we find that the jet power relates to the black hole mass as P_{jet}/L_{Edd}~0.036 where P_{jet} and L_{Edd} is the jet power and the Eddington luminosity, respectively. We further find that HBLs have the mass loading efficiency of \dot{M}_{jet}/\dot{M}_{acc}~6x10^{-3}, where \dot{M}_{jet} and \dot{M}_{acc} is the mass outflow and inflow rate, respectively. The inferred baryon mass loading efficiency of HBLs in our study is marginally consistent with recent 3D global general relativistic magnetohydrodynamic simulations for the jet launching from radiative-inefficient accretion flows. We further investigate the particle acceleration efficiency of low power AGN jets in the blazar zone by including the most recent Swift/BAT hard X-ray spectral data. Our HBL samples ubiquitously have the particle acceleration efficiency of eta_g~10^4, which is inefficient to accelerate particles up to the ultra- high-energy-cosmic-ray (UHECR) regime in the jets. This implies that the UHECR acceleration sites should be other than the blazar zones of quiescent low power AGN jets, if one assumes the one-zone SSC model based on the DSA theory. The paper is available from arXiv:1603.07623.

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## Järvelä, Emilia

*Narrow-line Seyfert 1 galaxies: the perplexing jetted spirals.*

Our understanding of active galactic nuclei (AGN) and the related jet phenomena was challenged when Fermi detected gamma-rays from a handful of narrow-line Seyfert 1 galaxies (NLS1s), thus confirming the presence of fully developed relativistic jets in them. The differences between NLS1s and other gamma-ray emitting AGN are pronounced; NLS1s have lower mass black holes, higher accretion rates, preferably compact radio morphology, they reside mostly in spiral galaxies, and were thought to be radio-quiet. It is now necessary to revise the AGN unification schemes to fit in NLS1s. Fermi's discovery also provokes questions about what triggers and maintains the AGN activity, and what are the evolutionary lines of the different populations. NLS1s complicate the whole AGN scenario, but also offer a new perspective on the jet phenomena. Despite their importance, NLS1s are poorly studied and observations of them are scarce; we need more observations and extensive studies of them as a class. For example, some NLS1s seem to be totally radio-silent, but a considerable fraction are radio-loud and thus probably host jets. This, along with other observational evidence, implies that they do not form a homogeneous class. However, it remains unclear what is triggering the radio loudness in some of them, but, for example, the properties of the host galaxy and the large-scale environment might play a role. We used various statistical methods, for example, multivariable correlations and principal component analysis to study a large sample of NLS1 sources. We will present the results and discuss the interplay between their properties, such as emission properties, black hole masses,

large-scale environments, and their effect on radio loudness. We will also introduce the Metsähovi Radio Observatory NLS1 galaxy observing programme, which is the first survey dedicated to systematical observations of NLS1s at high radio frequencies, and show some results for individual sources.

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## Jermak, Helen

*Observations of Possible Jet Formation*

In November-December 2015 the secondary supermassive black hole of the OJ287 binary system interacted with the accretion disk of the primary source causing a predicted flare in optical wavelengths, attributed to disruption in the accretion disk (see Valtonen et al. 2016). Shortly after the first, a second flare occurred which was joined by a simultaneous optical degree of polarisation flare- the highest on record- reaching ~40% polarisation. This second flare, with its polarised emission, could be the result of the formation of a relativistic jet from the secondary supermassive black hole after its gravitational influence has accreted matter from the primary accretion disk. It could also be non-jetted emission associated with accretion disk collision or emission from the primary's jet. I present intensive optical photometric and polarimetric monitoring of this second flaring event, along with Fermi gamma-ray data.

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*The RINGO2 and DIPOL Optical Polarisation Catalogue of Blazars*

We present 2000 polarimetric and 3000 photometric observations of 15 gamma-ray bright blazars over a period of 936 days (11/10/2008 - 26/10/2012) using data from the Tuorla blazar monitoring program (KVA DIPOL) and Liverpool Telescope (LT) RINGO2 polarimeters (supplemented with data from SkyCamZ (LT) and Fermi-LAT gamma-ray data). In 11 out of 15 sources we identify a total of 19 electric vector position angle (EVPA) rotations and 95 flaring episodes. We group the sources into subclasses based on their broadband spectral characteristics and compare their observed optical and gamma-ray properties. We find that (1) the optical magnitude and gamma-ray flux are positively correlated, (2) EVPA rotations can occur in any blazar subclass, 4 sources show rotations that go in one direction and immediately rotate back, (3) we see no difference in the gamma-ray flaring rates in the sample; flares can occur during and outside of rotations with no preference for this behaviour, (4) the average degree of polarisation (DoP), optical magnitude and gamma-ray flux are lower during an EVPA rotation compared with during non-rotation and the distribution of the DoP during EVPA rotations is not drawn from the same parent sample as the distribution outside rotations, (5) the number of observed flaring events and optical polarisation rotations are correlated, however we find no strong evidence for a temporal association between individual flares and rotations and (6) the maximum observed DoP increases from 10% to 30% to 40% for subclasses with synchrotron peaks at low, intermediate and high frequencies respectively.

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*The World's Largest Robotic Telescope*

I will highlight the design and progress of the new Liverpool Telescope 2; a new, fully robotic optical/infrared telescope planned to be located at the Observatorio del Roque de los Muchachos (ORM) on the Canary island of La Palma. The new, larger (4 metre-segmented mirror) telescope will build on the success of the Liverpool Telescope (LT) in transient astronomy and its study of the variable sky. The LT is the world's largest fully autonomous robotic observatory and houses 3 spectrographs, 1 polarimeter, 2 optical imaging cameras, 1 infrared imaging camera and three piggy-back optical cameras and is located on ORM. The new robotic telescope will have a faster slew time (allowing an even more rapid response to transients, particular those electromagnetic counterparts to gravitational wave events) and a larger aperture allowing for deeper exploration. The new robotic telescope will act as a key spectroscopic follow-up facility for the large-scale facilities such as LSST and CTA.

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## Karamanavis, Vassilis

*Nuclear opacity, magnetic fields, and the location of γ rays in the blazar PKS 1502+106*

The origin of blazar variability is still a heavily debated matter and broadband flares offer a unique testbed towards a better understanding of these extreme objects. An energetic outburst, from gamma rays down to radio wavelengths, was observed from the blazar PKS 1502+106 in 2008. The radio flare is studied through single-dish flux density measurements at 12 frequencies in the range 2.64 to 226.5 GHz. To quantify it, we employ both a Gaussian process regression and a discrete cross- correlation function analysis. Through the delay between flare maxima at different radio frequencies, we study the frequency-dependent position of the core and infer its absolute position with respect to the jet base. This nuclear opacity profile enables the magnetic field tomography of the jet. We also localize the gamma-ray emission region and explore the mechanism producing the flare. We find that the light curve parameters (flare amplitude and cross-band delays) show a power- law dependence on frequency. Delays decrease with frequency, and the flare amplitudes increase up to about 43 GHz and then decay. This behavior is consistent with a shock propagating downstream the jet. The self-absorbed radio cores are located between about 10 and 4 pc from the jet base and their magnetic field strengths range between 14 and 176 mG, at the frequencies 2.64 to 86.24 GHz. Finally, the gamma-ray active region is located at (1.9 +/- 1.1) pc away from the jet base.

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## Keck, Mason

*Probing Blazar Jets Closer to the Black Hole via Faraday Rotation Measurements*

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We present Very Long Baseline Array total and polarized intensity images of ten blazars obtained simultaneously at 22, 43, and 86 GHz in 2014 May. We aim to study the Faraday rotation measure and degree of polarization at the location of the 86 GHz VLBI core, closer to the black hole than previous analyses done at lower frequencies. The goal of the project is to probe the nature of the Faraday rotation screen and structure of the magnetic field geometry in the inner parsec-scale jet. Alignment of the total intensity maps at different frequencies will allow us to analyze the shape of the jet closer to its base.

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## Kravchenko, Evgeniya

*Radio and gamma-ray study of the quasar S4 1030+611 during its activity in 2009-2014*

We present a study of the parsec-scale multi-frequency polarization properties of the quasar S4 1030+61 during a prolonged radio and gamma-ray activity. Observations were performed by the Fermi Gamma-ray Space Telescope, VLBA and OVRO 40-m telescope covering five years starting from 2009. The quasar has stable, straight jet well described by standard conical jet theories. Observations cover a strong gamma-ray flare in the source accompanied by a high radio activity and observed emergence of a new parsec-scale jet component. Radio flaring activity of the quasar results from an injection of relativistic particles and energy losses at the jet base, where gamma-ray emission originates.

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## Liodakis, Ioannis

*F-GAMMA: Multiwavelength Variability Doppler factors*

Understanding the relativistic effects holds the key to uncovering the true nature of blazars and their jets. To that end, several methods have been proposed in order to estimate the Doppler factor (ie the amount of the relativistic boosting). Using population models were recently able to show that the variability Doppler factors is the only method that can adequately describe both the BL Lac object (BL Lacs) and Flat Spectrum Radio Quasar (FSRQ) populations with on average 30% error on each estimate. We built on this method by using sophisticated and specially designed algorithms and multi-wavelength radio lightcurves (from 2.64 to 142.33 GHz) in order to estimate the Doppler factor for 58 sources of the F-GAMMA program. Our novel and innovative approach allows us to effectively constrain the variability brightness temperature, overcome the limitations of previous attempts, and produce the most accurate Doppler factor estimates yet with 15% error on average. We will then use these estimates to clear the fog of the relativistic effects and look straight in the heart of the blazar central engines.

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## Liu, Xiang

*Correlation analysis of jet power, accretion rate and black hole spin*

We find that the accretion-dominated jet power has a linear proportionality with the accretion rate, whereas there are flatter power law indexes for low luminosity AGN at lower accretion rates. The latter could be due to the contribution of black hole spin, and this may allow us to find high-spin black holes in the low-luminosity AGN.

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## Liu, Yi

*Multifractal Simulation of Fermi Blazar Light Curves*

In this work, we'll present the multifractal simulation of Fermi Blazar light curves.

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## Lyutikov, Maxim

*On the Linear Stability of Sheared Magnetized Jets*

We consider MHD stability of sheared magnetized jets. We find that a special type of magnetic field structure - with the return current confined within a jet are particularly stable. Also, shear has a strongly stabilizing effect on various modes of jet instability.

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## Malmrose, Michael

*Dertermining the Relative Contribution of Different Emission Components to the Optical-UV Spectrum of Gamma-Ray Bright Blazars*

In the small fraction of active galactic nuclei (AGN) classified as blazars, one may occasionally observe relatively unprocessed radiation from the accretion disk. In the spectral energy distribution (SED) this produces a feature in the optical-UV portion of the spectrum known as the big blue bump (BBB). In Blazars, however, the relative strength of emission from synchrotron radiation is still significant in this region of the electromagnetic spectrum, complicating direct measurements of the BBB luminosity. Decoupling the portion of the SED produced by synchrotron radiation from that produced by the accretion disk can be accomplished through the use of spectropolarimetric observations. The spectral index, $\alpha_{s}$, of the synchrotron emission is revealed from observations of the polarized flux spectrum of a blazar

spanning from $\lambda = $ 4000-7000 $\aa$ in the observer's frame. The BBB emission is then obtained by fitting a two component model of the form $F_{\nu} = A nu^{- \alpha_{s}} + B nu^{-\alpha_{BBB}}$ to the full spectrum and fixing $\alpha_{BBB}$, the spectral index of the BBB, to -1/3. By deconstructing the spectra this way for $\gamma$-ray bright blazars insight can be gained into the stability of the BBB over the course of several years as well as provide clues to any wavelength dependence of the polarized emission.

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## Manganaro, Marina

*The blazar S5 0716+714 MWL picture during its brightest outburst*

S5 0716+714 is a well known BL-Lac object, located at a redshift of z~0.31. Its discovery in the Very High Energy band (VHE >100 GeV) by MAGIC happened in 2008. In January 2015 the source went through the brightest optical state ever observed, triggering MAGIC follow-up and a VHE detection with ~13 sigma significance (ATel #6999). The data, combined with simultaneous Fermi-LAT observations in the High Energy (HE, 100 MeV < HE <100 GeV) band allows us to constrain the Inverse Compton peak of the spectrum. Rich multiwavelength coverage of the flare allowed us to construct broad-band spectral energy distribution of S50716+714 during its brightest outburst. In this work we will present the preliminary analysis of MAGIC and Fermi-LAT data of the flaring activity in January and February 2015 for the HE and VHE band, together with radio (Metsahovi, OVRO, VLBA, Effelsberg), sub-millimeter(SMA), optical (Tuorla, Perkins, Steward, AZT-8+ST7, LX-200, Kanata), X-ray and UV (Swift-XRT and UVOT), in the same time-window. We furthermore discuss the time variability of the MWL light curves during this impressive outburst. AA preliminary study of the Extragalactic Background Light absorption and implications for EBL models will also be presented.

*Blazar PKS1441+25 at the Cosmic Gamma-ray Horizon: MWL description of a recent MAGIC discovery*

We will report on the discovery of the z~1 blazar PKS1441+25 in the very-high-energy range (VHE >100GeV) by MAGIC, a system of two 17 m of diameter Imaging Atmospheric Cherenkov Telescopes (IACTs) located in the Canary island of La Palma. For IACTs like MAGIC, such a redshift is very challenging due to the strong absorption of the extragalactic background light (EBL). The record for the farthest source ever detected in the VHE range is held by MAGIC, with the gravitationally lensed blazar B0218+357 detected in July 2014, at a redshift of z=0.944, and later on, the detection in April 2015, of the Flat Spectrum Radio Quasar PKS1441+25 at redshift z=0.939. In this contribution we will report on the discovery of the blazar PKS1441+25, and we will discuss how the exploration of the higher redshift Universe in VHE is helping in constraining the EBL evolution. We will show results on MAGIC analysis of PKS1441+25, including lightcurves, spectral energy distributions and EBL absorption studies, in a multi-wavelength context. The simultaneous multi-wavelength dataset collected (Fermi-LAT, NuSTAR, Swift XRT and UVOT, KVA, Hans-Haffner, CANICA, Metsähovi) allows us to test accurately for the first time the present generation of EBL models at such distances.

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## Meng, Nankun

*Intra-night Optical Variability of BL Lacertae*

We monitored BL Lacertae simultaneously in the optical B, V, R, I bands for 13 nights during the period 2012-2016. We studied its optical flux and spectral variations, and searched for inter-band time lags. The source was active on all 13 nights and showed significant intraday variability especially on one night in the B and I bands. A strong bluer-when-brighter chromatism was found on the intra-night timescale. The spectral changes are not sensitive to the host galaxy contribution. Cross correlation analysis revealed possible time delays of about 10 mins between variations in the V and R bands.

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## Molina, Sol Natalia

*Internal rotation and toroidal magnetic field in the inner jet of NRAO150*

NRAO 150 is a very prominent millimeter to radio emitting quasar at redshift z = 1.52. In previous studies (Agudo et al. 2007) this source has revealed a fast counterclockwise rotation of the innermost regions of the jet. Since this process is observed in the innermost regions of relativistics jets and must therefore be closely related to the properties of the regions where the jet is formed, collimated, and accelerated, the understanding of this process could be a very useful tool to study the physical process in the innermost part of jets. Despite this the physical origin of this process is still far from being well understood. With the aim to contribute to the understanding of this process we have developed a multi-frequency study at 8,15,22,43 and 86 GHz, analysing in particular the polarization and the cinematic behaviour.

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## Morozova, Daria

*Optical Outburst of the blazar S4 0954+658 in early 2015*

We analyze behaviour of the BLLac object S4 0954+658 during an unprecedented bright optical flare in early 2015. Optical flare was accompanied with powerfull gamma-ray flare and detection of the VHE-emission (ATel #7080). We analyzed total and polarized intensity images obtained with the VLBA at 43 GHz and discovered new bright polarized superluminal knot which passed through the VLBI-core during the maximum of the flare. Such close connection between the events in different wavebands supports the conclusion that optical and gamma-ray emission are produced in a region located in the

vicinity of the mm-wave core of the jet.

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## Motter, Juliana Cristina

*18-22 cm VLBA observational results for six AGN Jets*

The formation of relativistic jets in Active Galactic Nuclei (AGNs) is related to accretion onto their central supermassive black holes, and magnetic fields are believed to play a central role in launching, collimating and accelerating the jet streams from very compact regions out to kiloparsec or megaparsec scales. The radio emission of AGN jets is synchrotron radiation, which can be linearly polarized up to about 75%. We have analyzed Very Long Baseline Array (VLBA) total intensity, linear polarization, fractional polarization and Faraday rotation maps based on VLBA data obtained at four wavelengths in the 18–22 cm range for six AGNs in the MOJAVE–I sample. These observations typically probe projected distances out to tens of parsecs from the observed core, and are well suited for Faraday rotation studies due to the relatively long wavelengths used and the similarity of the structures measured at the different wavelengths. The linear polarization images show interesting structure along and across the jets in a number of cases. We have also identified statistically significant, monotonic transverse Faraday rotation gradients across the jets of some of these sources, indicating the presence of a toroidal magnetic field, which may be one component of helical magnetic fields associated with these AGN jets.

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## Myserlis, Ioannis

*Physical conditions and variability processes in AGN jets through multi-frequency linear and circular radio polarization monitoring*

The radio frequency emission of AGN jets is polarized due to the incoherent synchrotron mechanism. The polarization parameters carry information for the physical conditions and variability processes in the jet regions where the radiation is emitted and propagated through, e.g. the magnetic field properties or the plasma composition. However, the detection of their polarized components, especially the circular one, is challenging due to their low levels and possible depolarization effects. We present the multi-wavelength linear and circular polarization properties of 87 AGNs measured by the F-GAMMA program. The dataset spans from 2010 to 2015 and includes 10 radio frequencies between 2.6 and 142.3 GHz with a mean cadence of 1.3 months. We recovered the linear polarization properties at 4 frequencies between 2.6 and 10.5 GHz and the circular polarization at 4.9 and 8.4 GHz. Our analysis eliminates a number of systematics bringing the uncertainty to levels as low as 0.1%, essential for the inherently low circular polarization degree. Furthermore, we implement a polarized radiative transfer code that attributes the variability to evolving internal shocks, to investigate the

conditions and processes needed to reproduce the observed polarization behavior. This model was successfully applied for the blazar 3C454.3. Here, we present population studies based on the radio polarization data of the observed sources and the results of the model application for 3C454.3.

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## Nakahara, Satomi

*Conical stream line of approaching and counter jet in NGC 4261 over the range of 10^6 Rs*

We report the profile of jet width on both side at the radial distance ranging of ~10^3 - 10^9 Schwarzschild radii from the central engine of nearby(~30 Mpc) AGN NGC 4261. We investigated jet structures using Very Large Array(VLA) and Very Long Baseline Array(VLBA). The jets maintain a conical structure in both sides over the range of 10^6 Schwarzschild radius without any structural change ("jet break") like the approaching jet of M87. Our result on NGC 4261 may request an additional consideration to theoretical models of jet structure.

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## Pasetto, Alice

*Exploring the environment of high Rotation Measure Active Galactic Nuclei with wideband radio spectropolarimetry observations.*

We present new high sensitivity wide-band full polarization observations of a sample of Active Galactic Nuclei observed with the JVLA. This sample contains objects with very high Rotation Measure (RM) values, sign of extreme environment of the AGN. We study their radio spectral energy distributions and their polarization properties in the well-sampled frequency range between 4 and 12 GHz. We found that the polarization properties show a complex behaviour with the polarization angle and the fractional polarization that dramatically change within the wide-band. The strong depolarization experienced by the sources, have been studied through a complex modelling of the Stokes parameters Q and U together with the fractional polarization and the polarisation angle with wavelength by applying combinations of the simplest existing depolarisation models. This study suggest the presence of several Faraday layers within or in front of the observed emitting region each of them with extreme polarized conditions. This points the complexity of these objects; they not only could have dense clumpy regions surrounding the central engine but also could be characterised by a dense wind that envelops the relativistic jet.

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## Piner, Glenn

*Parsec-Scale Structure and Kinematics of Faint TeV HBLs*

We present new multi-epoch Very Long Baseline Array (VLBA) observations of a set of TeV blazars drawn from our VLBA program to monitor all TeV-detected high-frequency peaked BL Lac objects (HBLs) at parsec scales. Most of these sources are faint in the radio (with flux densities of order 10 millijanskys), so they have not been well observed with VLBI by other surveys. Our previous measurements of apparent jet speeds in of order a dozen TeV HBLs showed apparent jet speeds that were subluminal or barely superluminal; suggesting jets with velocity structures at the parsec-scale. Here we present apparent jet speed measurements for eight new TeV HBLs, which for the first time show a superluminal tail to the apparent speed distribution for the TeV HBLs.

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## Pursimo, Tapio

*Optical Spectroscopic Characterization of Unidentified Gamma-ray Sources*

In the last gamma-ray catalogue from the {\it Fermi}-LAT, 3FGL, the number of established GeV- gamma-ray sources increased by 60\% (from 1873 to 3055 objects). The great majority of these sources (56\%) are blazars (AGNs whose relativistic jets point towards the Earth). About 20\% of these sources have an unclassified optical counterpart (classified as unidentified AGNs or AGU) due to the lack of optical spectroscopic information. This lack of spectroscopy prevents the full exploitation of the data, since the spectral classification and the distance of the source (redshift) are crucial to infer their intrinsic emission. We present preliminary results from our on-going programme for spectroscopic classification of AGUs. These include low resolution spectra for 16 sources, all of which have featureless spectrum. The results and the implications for the full sample are discussed.

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## Rajput, Bhoomika

*The connection between optical and GeV flux variations in blazars*

The extragalactic gamma-ray sky is dominated by the blazar class of active galactic nuclei (AGN). These sources with their relativistic jets pointed close to be observer show flux variations over the entire accessible electromagnetic spectrum. By studying flux variations over multiple wavelengths one can probe the multi-wavelength emission sites in blazar jets. According to the leptonic model, the flux variations in the optical and GeV bands of blazars need to the correlated. Alternatively, in the hadronic scenario of emission from blazar jets, a correlation between flux variations in the optical and GeV bands is not expected. To probe the possible connection between optical and GeV emission mechanism in blazar jets (leptonic v/s hadronic scenario), we are carrying out

a systematic study on the opitcal and GeV flux variations on a large sample of blazars detected by the Fermi Gamma-ray Space Telescope. Our preliminary results indicate that blazars show a wide range of variability patterns such as (a) correlated optical and GeV flux variations with/without time lag, (b) optical flares with no GeV counterparts and (c) GeV flares with no optical counterparts. Details of the results will be presented.

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## Saikia, Payaswini

*Using the Black hole Fundamental Plane to constrain Blazar Jet physics*

Black hole accretion disc and its associated jets form a coupled system, which is thought to scale globally across the entire black hole mass range - from the stellar mass X-ray Binaries to the supermassive Active Galactic Nuclei. One of the main findings supporting scale invariance of accretion and jet physics is the Fundamental Plane of Black Hole activity, which is an empirical relation between radio luminosity, X-ray luminosity and black hole mass for low-accretion rate black holes. Using a sample of 39 AGN selected from the Palomar Spectroscopic Survey, 4 stellar mass X-ray binaries in the low/hard state and 82 blazars from the VLBA Imaging and Polarimetry Survey, we report the discovery of the fundamental plane in the optical band with the luminosity of nuclear [OIII] emission line as a tracer of accretion rate. This plane can be obtained with the supermassive black hole sample alone and can be used to study the radio-loudness of different AGN types. We show that after accounting for the non-linearity in the radio-[OIII] luminosity correlation and by including a mass-scaling factor, we see no clear radio-dichotomy in the different types of AGN in our sample. Finally, we use this plane to provide insights on the underlying distributions of important blazar parameters (eg. opening angles, Lorentz factor distribution) and use them to put constraints on black hole jet physics.

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## Sasada, Mahito

*Stochastic study of microvariability in Kepler blazar W2R 1926+42*

One of the remarkable features in blazars is violent variability over a wide wavelength range. The variation mechanism is still under debate, since the behavior of the variability is very complex. The timescales of variability range from less than a day to decades, with variations on timescales less than a day known as microvariability. Such short-term variations can provide insights regarding the origin of variability after they are distinguished from longer-term variation components. We select about 200 microvariability events from the high-time-resolution and continuous light curve of the blazar W2R 1926+42 obtained by the Kepler spacecraft, and estimate the timescale and amplitude of each event. The rise and decay timescales of the events change both randomly and systematically with time. This result indicates that the events are

associated with each other, not independently.

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## Sbarrato, Tullia

*Hidden parents of high-z blazars: quenching and dark bubbles*

At redshift larger than 3 a relevant disagreement arises between the number of blazars (with jets aligned to our line-of-sight) and their parent population (with jets pointing elsewhere). We are missing the high-redshift blazars misaligned counterparts in our optical and radio surveys. Are we losing the optical nuclear emission or the extended radio flux? On one side, we could be missing the most misaligned sources, whose radio emission from their extended structures is likely quenched by the CMB energy density. But we also find a discrepancy between blazars and their slightly misaligned counterparts: we are missing slightly misaligned jets, too. This cannot be ascribed only to a quenched extended emission. I will show that an over-developed dusty structure can account for the missing misaligned population: "bubbles" of dust covering the nuclear region could completely obscure it. The jet can pierce the bubble, leaving visible the optical nucleus only if observing down the jet axis. This hypothesis would justify the relevant lack of parents, compared to the number of blazars that we keep finding at z > 4.

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## Shastri, Prajval

*Synchrotron Jets, their Parsec-scale Environments and the Blazar Divide*

Current data at gamma-ray (Fermi), radio (MOJAVE, VLA) and other frequencies suggest that the parsec-scale environment of synchrotron jets leaves imprints on the relativistically beamed emission from the jets. We use these trends to test the hypothesis that the blazar divide constitutes a dichotomy. Obtaining a handle on the Doppler factor can play a key role in building a consistent picture of the jets and their relationship with the central supermassive black hole accretion system, especially in the framework of unification schemes. We will present our results from such an investigation.

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## Shukla, Amit

*Detection of very hard gamma-ray spectrum from nearby blazar Mrk 501*

The emission from active galactic nuclei ranges from radio to TeV energies and shows high variability. The origin of the very high energy (VHE) emission is highly debated. The

observed emission could be due to a complex superposition of emission from multiple zones. New evidence of the detection of very hard intrinsic gamma-ray spectra obtained from Fermi-LAT observations have challenged the theories about origin of VHE gamma-rays. We used 7 years of Fermi-LAT data to search for time intervals with unusually hard spectra from the nearby TeV blazar Mrk 501. In the presentation, we discuss a few possible explanations for the origin of these hard spectra within a leptonic scenario.

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## Sinha, Atreyee

*Lognormal flux variability in blazars: Observations and Implications*

Lognormality is an important statistical process found in many accreting sources like X-ray binaries. Lognormal fluxes have fluctuations, that are, on average, proportional to the flux itself, and are indicative of an underlying multiplicative, rather than additive physical process. It has been suggested that a lognormal flux behavior in blazars could be indicative of the accretion disk's variability imprint onto the jet. We discuss results from our long term light curve studies of blazars, where we clearly detect lognormality in Mkn421 across the entire electromagnetic spectrum, from radio to gamma-rays. This is the third time lognormality has been observed in blazars, following BL Lac (Giebels & Degrange 2009) and PKS 2155-304 (Chevalier et al. 2015). This can have important implications on disk-jet couplings in blazars, where lognormal fluctuations in the accreting rate give rise to an injection rate with similar properties. Title 2: Spectral Curvature in blazar SEDs Abstract 2: Measurement of the spectral curvature in blazar jets can throw light on the underlying particle spectral distribution, and hence, the acceleration and diffusion processes at play. With the advent of NuSTAR and ASTROSAT, and the upcoming ASTRO-H, this curvature can now be measured accurately across the broadband X-ray energies. We will discuss results from our works on two HBLs, Mkn421 (Sinha et al, AA 2015) and 1ES1011+496, and show how simultaneous measurement at hard and soft X-ray energies can be crucial in understanding the underlying particle spectrum. India’s recently launched multiwavelength satellite, the ASTROSAT will provide simultaneous time resolved data between 0.2-80keV, along with measurements at Optical-UV energies. We will also discuss prospects from ASTROSAT for studying jet triggering mechanisms in blazars.

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## Sinitsyna, Vera Georgievna

*Long-term studies of NGC 1275 at very high energies: the structure and emission origin*

We present the results of fifteen-year-long observations of the AGN NGC 1275 at energies 800 GeV - 40 TeV discovered by the SHALON telescope in 1996. Having analyzed the SHALON data, we have determined such characteristics of NGC 1275 as the spectral energy distributions and images at energies > 800 GeV for the first time. The

emission regions of very high energy gamma-rays observed by SHALON from NGC 1275 well correlates with the photon emission regions viewed in X-rays by Chandra. Thus, the TeV gamma-ray emission recorded by SHALON has an extended structure with a distinct core centered at the source's position. To analyze the emission related to this core, we additionally identified the emission component corresponding to the central region of NGC 1275, and got spectral energy distribution of this component as a result. Also, the variations of TeV gamma-ray flux were found. The data obtained at very high energies, namely the images of the galaxy and its surroundings, and the flux variability indicate that the TeV gamma-ray emission is generated by a number of processes: in particular, part of this emission is generated by relativistic jets in the nucleus of NGC 1275 itself. Whereas, the presence of an extended structure around NGC 1275 is evidence of the interaction of cosmic rays and magnetic fields generated in the jets at the galactic center with the gas of the Perseus cluster.

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**Sinitsyna, Vera Yurievna**

*Probing of distant FSRQ jet activity at very high energies*

The radio-loud active galactic nuclei having the radio emission arising from a core region rather than from lobes are often referred to as "blazars" and include Flat Spectrum Radio Quasars (FSRQ) and BL Lacertae (BL Lac) objects. The SHALON observations yielded data on extragalactic sources of different type at energy range of 800 GeV - 100 TeV. During the period 1992 - 2016, SHALON has been used for observations of the FSRQ type: 4c+31.63 (z=0.295), 3c454.3 (z=0.859), 4c+55.17 (z=0.896), PKS1441+25 (z=0.939), 1739+522 (z=1.375). We present results of long term observations of FSRQ: among them are known object 3c454.3, high-red shifted quasar 1739+522 (4c+51.37) and 4c+31.63, 4c+55.17. The observation results are presented with integral spectra, images and spectral energy distributions for each of sources at energies above 800 GeV. The data from SHALON observations are compared with ones from experiments at high and very high energies. A number of variability periods in different wavelengths including VHE gamma rays were found. For example 3c454.3 shows the significant flux variability in the different energy ranges including high and very high energies. The last significant flaring state of 3c454.3 at TeV energies was detected in the SHALON observational period of Nov. - Dec. 2010.This increase is correlated with the flares at lower energy range in observations of Fermi LAT. Also, the observations of high-redshift (z>2) sources have been started in autumn-winter period of 2014 year. The results on B2 0242+43 (z = 2.243) and B2 0743+25 (z = 2.979) quasars from first and second Fermi LAT AGN catalogue are presented.

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## Sitarek, Julian

*Gamma-ray variability induced by microlensing on intermediate size structures in lensed blazars.*

Strong gravitational lensing results in an appearance of multiple, differently magnified images of a lensed source. As shown by the detection of very-high-energy gamma ray emission from a lensed blazar QSO B0218+357, this effect is opening new possibilities in studying the emission proprieties of such blazars. Moreover, the magnifications of individual images can be modified by microlensing on smaller mass scales within the lens. Recently, measurements of the changes in the magnification ratio of the individual images have been proposed as a powerful tool for estimation of the size and velocity of the emission region in the lensed source. The changes of the magnification ratios in blazars PKS1830-211 and QSO B0218+357, if interpreted as caused by a microlensing on individual stars, put strong constraints on those two variables. These constraints are difficult to accommodate with the current models of gamma-ray emission in blazars. We study whether similar changes in the magnification ratio can be caused by the microlensing on the intermediate size structures in the lensing galaxy, namely stellar clusters and giant molecular clouds. Our numerical simulations show that changes in the magnification ratio of two images, with similar time scales as seen in QSO B0218+357, can be obtained for relativistically moving emission regions with sizes up to 0.01 pc in the case of microlensing on clumps in giant molecular clouds.

*Broad band observations of gravitationally lensed blazar B0218+357 during a gamma-ray outburst.*

B0218+357 is a blazar located at a cosmological redshift of z=0.944. The source is gravitationally lensed by a spiral galaxy located at the redshift of z=0.68. Strong gravitational lensing splits the signals emitted by the source into two components separated by 10-12 days, as observed in radio and gamma-ray bands. In July 2014 a GeV flare was observed by Fermi-LAT, triggering follow-up observations with the MAGIC telescopes at energies above 100 GeV. The expected time delay between the components allowed us to plan broad band MWL observations before, during and after the trailing component of the emission. The MAGIC observations at the expected time of arrival of the trailing component resulted in the first detection of B0218+35 in very-high-energy (>100 GeV) gamma rays. It is both the farthest known VHE object and one of only a few Flat Spectrum Radio Quasars detected in this energy range. We report here the observed multiwavelength spectral and temporal properties of the emission during the 2014 flare. We will present also broad band spectral modeling in the external Compton scenario.

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## Sohn, Bong Won

*Recent results of KaVA AGN WG*

KaVA stands for KVN and VERA Array. KaVA AGN WG recently launched Large Program

(LP) and other programs. I will briefly review recent KaVA AGN WG results.

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## Strigachev, Anton

*The extremes in intra-night blazar variability: the S4 0954+65 case*

We present results of optical observations of an extremely violently variable blazar S4 0954+65 on intra-night time scales. The object showed flux changes of up to 100% within a few hours. Possible time delays between optical bands are searched for and the results are discussed in terms of existing models of blazar variability.

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## Troitskaya, Yulia

*The multiwavelength monitoring of the gamma-bright blazar Mkn 421*

We present the results of photo-polarimetric and spectral monitoring observation of the blazar Mkn 421 carried out at different telescopes (the 0.4 m telescope of SPbSU, the 0.7 m telescope of the Crimean Astrophysical Observatory , the 2.3 m and 1.54 m telescopes of Steward Observatory) during 2008-2015. We also analyze gamma-ray light curves obtained with the Fermi Large Area Telescope. The multiwavelength flux and polarization variations and the optical spectral behaviour are discussed.

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## Troitskiy, Ivan

*Multifrequency monitoring of the flat spectrum radio quasar PKS 1222+216*

We analyze broadband activity of the flat radio spectrum quasar PKS 1222+216 from 2008 to 2015 using multifrequency monitoring which involves gamma-ray data from the FERMI Large Area Telescope, total intensity and linear polarization observations from different optical telescopes in R band, and imaging of the inner jet structure with the VLBA at 43 GHz. During the observations the source has several dramatic flares at gamma rays and optical bands, with the rising branch of a gamma-ray flare accompanied by a rapid rotation of the polarization position angle (EVPA), a fast increase of the degree of polarization in the optical band, brightening of the VLBI core, and appearance of a new superluminal component in the parsec-scale jet. We find a statistically significant correlation between gamma-rays, optical R band, and 43 GHz variability on a long-term scale and a good general alignment between EVPAs in R band and at 43 GHz, while the correlation between short-term variations is not apparent. Synchronous activity across the bands supports the idea that the emission regions responsible for the flares in gamma-rays and optical band are co- spacial and located in the vicinity of the mm-wave core of the parsec-scale jet. The rapid variability of the optical linear

polarization points to strong turbulence in the jet plasma.

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## Uemura, Makoto

*TimeTubes: Visualization of polarization variations in blazars.*

Optical polarization provides important clues to the magnetic field in blazar jets. It is easy to find intriguing features in the time-series data of the polarization degree (PD) and position angle (PA). On the other hand, the trajectory of the object on the Stokes QU plane becomes essential when the object has multiple components of polarization. In this case, ironically, the more data we have, the more difficult it is to gain any knowledge from it. Here, we introduce TimeTubes, a new visualization scheme to explore the time-series data of polarization observed in blazars. In TimeTubes, the data is represented by tubes in 3D (Q, U, and time) space. The measurement errors of (Q,U), color and total flux of objects can be expressed as the size, color and brightness of the tubes. Then, TimeTubes allow us to see variations of six variables in one view. We used TimeTubes for our data taken by the Kanata telescope between 2008 and 2014. We found that this tool facilitates the recognition of the patterns in blazar variations; for example, i) favored PA of flares (ex. PKS 1502+106, PKS 1749+096, and QSO B0133+47), ii) PA rotations associated with a series of flares (3C 454.3), and iii) off-center PA rotation superposed on long-term trends (PKS 2155-304), as well as standard PA rotations (3C 454.3 and PKS 1749+096). We show some demonstrations of TimeTubes in my presentation.

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## Villacaña Pedraza, Ilhuiyolitzin

*Multifrequency study of 3C454.3*

In this work I presented a multifrequency syudy of 3C454.3, the study included spectroscopy and photometry observed in optical and IR(OAGH 2m telescope), FERMI telescope and VLA array.

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## Wehrle, Ann

*Optical observations of OJ 287 and other blazars with the K2 mission*

We present optical observations of OJ 287 and several other gamma ray blazars carried out with the K2 mission (formerly Kepler) in 2015. The observations were continuously sampled at 30-minute intervals for approximately 75 days. In addition to these highly variable blazars, we have observed several hundred radio-loud and radio-quiet AGN with the K2 mission in order to characterize the amplitude and duty cycle of their optical

variations.

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## Williamson, Karen

*Comprehensive Monitoring of Gamma-Ray Bright Blazars. II. Time Series Analysis of Delays Between Variations in Gamma-Ray, X-Ray, and Optical Light Curves*

The BU team has been performing multi-wavelength monitoring of a sample of gamma-ray blazars since the launch of the Fermi Large Area Telescope in the Summer 2008. We present gamma-ray, X-ray, and optical light curves for several quasars and BL Lac objects from the sample to demonstrate different patterns of the variability. We investigate possible correlations between γ-ray and X-Ray, γ-ray and R-band, and X-ray and R-band light curves to study delays between variations at different wavelengths, if a statistically significant correlation is found. To perform the correlation, we use the Z-transformed Discrete Correlation Function algorithm (ZDCF), and to test the significance of ZDCF, we simulate artificial light curves using actual observational data. The location of the emitting regions in AGN jets and the origin of the high-energy photons are questions that may be answered by a better understanding of the time delays between different wavebands. We will present preliminary results of the analysis. In spite of 8 years of active monitoring, our correlation analysis remains plagued with uncertainties due to sparsity of the data.

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## Wu, Jianghua

*Inter-band time lag of optical variabilities of blazar S5 0716+714*

Time lags among the radio, optical, X-ray, and gamma-ray variabilities of blazars are sometimes been reported in the literature, but very few such lags were claimed between the variabilities at different optical wavelengths. We carried out multi-band optical monitoring of blazar S5 0716+714 with high temporal resolutions at several epochs. Inter-band time lags were detected in the optical variability of this object with high confidence level. This can be taken as a support for the shock model of blazars.

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## Yuhai, Yuan

*Short-term optical variability of blazars*

In this work, we present the VRI photometric observations of 1ES1959+650 obtained by using the 1.56m telescope at Shanghai Observatory (ShAO), China, during the period from Jun. 11, 2006 to Jul. 31, 2014. Our observations show that the maximum

variabilities at three bands are $\Delta m_{V}=1.74\pm0.02$ mag, $\Delta m_{R}=0.97\pm0.02$ mag and $\Delta m_{I}=1.15\pm0.03$ mag. We obtained two intra-day variabilities on Sep. 2, 2009 (JD 2455077) and Sep. 3, 2009 (JD 2455078). On Sep. 2, 2009, the optical variabilities are $\Delta m_V = 0.36\pm0.08$ mag within 1.56 hours, $\Delta m_R = 0.21\pm0.04$ mag within 23 minutes; $\Delta m_I = 0.53\pm0.03$ mag within 45 minutes. On Sep. 3, 2009, the intra-day variabilities are $\Delta m_V = 0.40\pm0.10$ mag within 27 minutes, $\Delta m_R = 0.48\pm0.04$ mag within 3.24 hours; $\Delta m_I = 0.68\pm0.06$ mag within 3.72 hours. We use the Power spectrum, the DCF method and the Jurkevich method to analyze the lightcurve and obtain three quasi-periodicities, $P_1=1.4\pm0.2$yr, $P_2=2.9\pm0.6$yr and $P_3=5.5\pm0.9$yr.

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## Zacharias, Michael

*Implications of time-dependent injection in relativistic jets*

Time-dependent injection can cause non-linear cooling effects, which lead to a faster energy loss of the electrons in jets. The most obvious result is the appearance of unique breaks in the SED, which would normally be attributed to a complicated electron distribution. The knowledge of the observation time and duration is important to interpret the observed spectra, because of the non- trivial evolution of the SED. Intrinsic gamma-gamma absorption processes in the emission region are only of minor importance.

*On the unusual SED of AP Librae and the origin of the TeV gamma-rays*

The LBL AP Librae has been detected in the TeV gamma-ray range, which is unexpected for this kind of blazar. In combination with other features of the SED, this rules out the one-zone model to account for the TeV domain. Furthermore, an extended jet on arcsec scales has been detected both in radio and X-ray frequencies. The spectral index of the X-ray band indicates an inverse Compton origin. Using an IC/CMB model, the TeV emission can be successfully modeled as originating in the extended jet. Several arguments in favor of this model as well as observational tests to check the model will be presented. If true, acceleration of particles to very high energies is still efficient at large distances to the core.

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## Zhang, Xiaoyuan

*Intra-day Simultaneous Optical Monitoring of S5 0716+714*

We present the result of simultaneous optical multi-color observation of BL Lac object 0716+714 in November 2014 and February 2016. The intra-day variability varies from

0.04 to 0.3 mag. Both achromatic and bluer-when-brighter color behaviours were detected. A probable quasi-periodic oscillation overlapping on a significant flare was also observed. We used the interpolated cross- correlation function to calculate time lags between light curves in different bands. Variations in B and R lagging behind that in I band was found, which correspond with anti-clockwise loops on the color-magnitude diagrams. Such an optical time delay can be interpreted by acceleration and cooling process of electrons in jet of the blazar.

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**Zola, Staszek**

*Preliminary results from 2015/26 observing campaign of the OJ287 blazar*

We will present the photometric data on OJ287 taken during the 2015/2016 observing season. Dense measurements were started at the onset of the Decemeber outburst (Valtonen et al. 2016) and we keep monitoring of this blazar with a cadence shorter than a day until mid May. Search for periodicities was performed over the entire dataset. Using the FT method, we found no stable periods above the 4-sigma confidence level in the November/December subset. A statistically significant period of about 3 days was detected with rFT in the peak of the December outburst, but it disappeared soon after the decline has started.