THE XIV FINNISH-RUSSIAN RADIO ASTRONOMY SYMPOSIUM

5.–7. September 2018,
Tuorla Observatory, Finland

ABSTRACTS

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About solar transition region structure according ALMA and RATAN-600 observations

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Knowledge of the altitude distribution of the temperature and density in the atmosphere of a sun spot is extremely important for understanding the process of energy transfer from the photosphere up to the corona in the presence of strong magnetic fields. The emergence of data in the millimeter and submillimeter waves at the new ALMA radioastronomical tool and the regular observations in the microwave range at the RATAN-600 provide the opportunity to conduct the first mapping and to obtain new information.

As part of the test company on ALMA, AR12470 solar observations [1] were carried out in December 2015 on waves of 1.3 mm and 3 mm.t The comparison of these observations with the data of regular microwave observations on RATAN-600 was carried out. The paper discusses the results obtained on the two instruments and their comparison with models of the solar atmosphere above the spot.

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Time Variability of the Core-Shift Effect in the Blazar 3C454.3

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The so-called core-shift effect in relativistic jets observed at radio wave bands has been widely studied and used for estimating physical parameters as the magnetic field strength and the particle number density. In this work, we have investigated the time variability of the core-shift effect in the very luminous blazar 3C454.3 (z=0.859). We have analysed multi-frequency (5,8,15,22,43 GHz) Very Long Baseline Array data of 19 epochs from 2005 to 2010. Core-shift measurements have been performed using image plane cross-correlation and visibility plane model-fitting. These measurements allow us to study the time variability of the core-shift in the blazar as well as the time evolution of the spectra. We compare our results with long-term 37 GHz total flux density monitoring observations made at the Metsähovi Radio Observatory searching for correlations. Our preliminary results show that the index k_r of the core-shift effect $r_{core} \propto \nu^{-1/k_r}$ varies in the range of $0.4 < k_r < 1.2$ during the observed time period. This result shows departures from a conical-jet structure. We suggest that this variability is mainly linked to the occurrence of outbursts. We will discuss the reliability of the core-shift measurements as a proxy for the jet magnetic field strength.

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The broad-band properties of the intermediate synchrotron peaked BL Lac S2 0109+22 from radio to VHE gamma rays

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The MAGIC telescopes observed S2 0109+22 in 2015 during its flaring activity in high energy gamma rays observed by Fermi -LAT. We analyse the MAGIC data to characterise the very high energy (VHE) gamma-ray emission of S2 0109+22, which belongs to the subclass of intermediate synchrotron peak (ISP) BL Lac objects. We compare the source long-term radio/optical behaviour to other VHE gamma-ray emitting (TeV) blazars. Long-term radio and optical data have also been investigated using the discrete correlation function. MAGIC observations resulted in the first time detection of the source at a significance level of 5.3 σ. The VHE gamma-ray emission of S2 0109+22 is variable on a daily time scale. The optical polarization, and long-term optical/radio behaviour of the source are different from the general population of TeV blazars. All these findings agree with the classification of the source as an ISP BL Lac object. In this contribution, we will present our findings focusing on the radio/optical variability of the source.

Long-Term and Rapid Radio Variability of the Blazar 3C 454.3 in 2010–2017

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The results of the blazar 3C 454.3 (J2253+1608) studies on RATAN-600 (SAO RAS) and 32-m Zelenchuk and Badary radio telescopes (Quasar VLBI Network) will be presented. Long-term variability of the radio emission is studied, as well as variability on time scales of several days and intraday variability (IDV). Two flares were detected in the long-term light curve, in 2010 and in 2015–2017. The flux density at 21.7 GHz increased by a factor of ten during these flares. The delay in the maximum of the first flare at 4.85 GHz relative to the maximum at 21.7 GHz was six months. The time scale for variability on the descending branch of the first flare at 21.7 GHz was τvar = 1.2 yrs, yielding an upper limit on the linear size of the emitting region of 0.4 pc, corresponding to an angular size of 0.06 mas. The brightness temperature during the flare exceeded the Compton limit, implying a Doppler factor δ = 3.5, consistent with the known presence of a relativistic jet oriented close to the line of sight. No significant variability on time scales from several days to several weeks was found in five sets of daily observations carried out over 120 days. IDV was detected at 8.57 GHz on the 32-m telescopes in 30 of 61 successful observing sessions, with the presence of IDV correlated with the maxima of flares. The characteristic time scale for the IDV was from two to ten hours. A number of IDV light curves show the presence of a time delay in the maxima in the light curves for simultaneous observations carried out on the Badary and Zelenchuk antennas, which are widely separated in longitude. This demonstrates that the IDV most like arises in the interstellar medium.

WWW-interface for controlling parameters of RATAN-600 spectrograph in remote access.

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The development of a specialized WEB-application for controlling the radiometric complex of the RATAN-600 radio telescope in the remote access mode was carried out. Regular observations of various celestial radio sources in different modes, including registration at many wavelengths, in many positional angles of the radio telescope (in many azimuths), with different registration parameters (amplification, time constants, dynamic range, etc.) are conducted on the radio telescope. For the observations commonly used computer program that operates on a specific time interval (days, weeks). However, it is often necessary to control the setpoints of management teams, as well as the mode of rapid change of the observation mode. A WEB application was created, which is designed for quick access to the control system of the RATAN-600 radiometric complex. It provides convenient control of the hardware complex from a mobile computer, has independence from the operating system of the radio telescope, no need to compile the application on different operating systems and more.

ALMA view of the nearest quasar 3C273

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3C273 is our nearest high-power radio-loud quasar, and as such it has been extensively studied since the 1960s. ALMA has now opened a new window for studying the jet of 3C273 at millimeter wavelengths. We will present results from a recent study where we observed the polarization of the source over the 1.3mm band at ALMA. Through modeling our observations, we were able to constrain the magnetic field structure near the jet launching region, opening a door for connecting observations of relativistic jets with theoretical jet launching simulations. Our observations also resolve the kpc-scale structure of the source, and preliminary analysis of the bright features in the jet indicates that the emission spectrum is more complex than previously thought. This may alter our understanding of the particle population and acceleration in the jet, and have a significant impact on the energetics of the source, and thus its impact on the surrounding large-scale environment.

Host galaxy morphologies of jetted narrow-line Seyfert 1 galaxies

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So far the host galaxy morphologies of only a few jetted narrow-line Seyfert 1 galaxies (NLS1) have been studied. Their number is too low to perform a meaningful comparison with the non-jetted NLS1 population, or to draw any conclusions on a preferred host galaxy type for jetted NLS1 sources. We used NOTCam at the Nordic Optical Telescope to observe the host galaxies of nine NLS1 sources in J-band. Seven of these have been detected at 37 GHz at Metsähovi Radio Observatory, suggesting that they host powerful jets. We performed photometric decomposition of the near-infrared images using GALFIT to determine the morphologies of the host galaxies. Here we present the results of the host galaxy modelling, and discuss their implications to our understanding of the diverse nature of the NLS1 population.

Forty years of solar radio observations at Metsähovi Radio Observatory

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The Aalto University Metsähovi Radio Observatory (MRO) in Finland began regular solar radio observations over 40 years ago, in 1978. It is one of the longest solar radio data collections at millimeter wavelengths, and the data have been widely used in the field of solar radio physics over the years. The main research topics have been microwave solar radio bursts, oscillations, and pulsations in various solar features, for example, radio brightenings and the overall long-term solar radio variability.

Currently, Metsähovi has four different solar radio instruments, operating at wide range of wavelengths from 8 mm to 60 m. Most of the solar observations have been made with the 13.7-m antenna at 8 mm [1], but data have also been collected at 3 mm and 1.3 cm. Radio brightenings at 8 mm are a good indicator of the general solar activity level. They show the phase of the solar cycle equally accurately as the traditional solar sunspot number. Other three instruments are focusing on observe solar radio burst at the wide radio spectra.

In this presentation, we give a short historical overview of the solar radio observations and research at MRO. In addition, we focus on more carefully recent solar activities and studies. These studies have been connected to a long-term variation of the solar radio brightening (e.g. [2] and [3]) and a single event analysis (e.g. [4]). Also the recent instrumentation additions and upgrades will be presented.

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Different types of solar active region magnetospheres observed in microwaves

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The active regions on the Sun are the complex formations spread from the photosphere spots through the chromosphere to the coronal loop arcades with various structures of open and closed magnetic fields [1]. Both the structure and the radio emission of the active regions are strongly regulated by magnetic fields.

We show the results of microwave observations by RATAN-600 of the magnetospheres of active regions with different types of magnetic classification (with and without spots, with small and developed coronal arcades). Measurements of spectral polarization characteristics of different types of active regions with a brief description of their index spectra, sizes, brightness temperatures and mechanisms of emission are presented. Evaluation of slopes of spectra shows that in many coronal arcades there is a constant admixture of non-thermal radiation. The introduction of a microwave classification taking into account both the complexity of the magnetic configuration and the features of the microwave spectra is proposed.

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Image recognition for historical solar maps

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Metsähovi Radio Observatory has collected solar intensity maps since autumn 1978. The maps have been recorded with the main radio telescope, which has a parabolic antenna with diameter 14 meters. The most common frequency is 37 GHz with beam diameter 2.4“. Occasional observations have been conducted, for example, on 22 GHz and 77 GHz. The was recorded on magnetic tapes or disks until 1987.

The original data is lost, but the maps have survived as mechanically rendered contour plots [1]. In order to convert scanned images of the maps into more usable format, I have written a software as my master's thesis [2] during spring 2018. After some filtering, all the markings on the maps can be interpreted. Contour lines can be converted into scalar intensity fields using a Poisson solver. The method is tolerant for various defects. In an electrical analogy, contour lines are treated as dipole charges which span an electric potential. Once the Poisson equation is solved for intact contours, the resulting potential field will be constant between the contours and have unit discontinuities at the contour lines. Broken contours appear as perturbations and can be eliminated with substitutions, which iteratively reduce the dimensionality of the said linear system. The algorithms used in this work are also suitable for interpreting historical solar magnetograms from Mount Wilson and Palomar observatories [3].

At present, Metsähovi is producing at least one solar intensity map every day, also during winter, and performs more than 12 hours of daily observations during summer. These recorded antenna samples have to be interpolated in order to produce scalar fields comparable with the historical data. Subsequently, I will identify bright and dim regions using an exhaustive sorting algorithm. This approach allows us to characterise the regions by their shape and amount of local extrema.

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Anisotropy of synchrotron radiation of the self-consistent current structures: the breaks and the hidden components

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Widespread use of a broken-power-law description of the spectra of synchrotron emission of various plasma objects requires an analysis of origin and a proper interpretation of spectral components. We show analytically that, for a self-consistent magnetic configuration in a collisionless plasma, these components may be angle-dependent according to an anisotropic particle momentum distribution and may have no counterparts in a particle energy distribution [1]. That is in contrast to a usual model of synchrotron radiation, assuming an external magnetic field and a particle ensemble with isotropic momentum distribution.

In a typical case of a self-consistent current sheet with the multi-power-law synchrotron spectral and particle distribution profiles, different power-law components have different anisotropies. As a result, the number of the synchrotron power-law components may be different at different observational angles. Also, in some frequency bands the so-called 'hidden' components appear, which would be negligible if calculated on the basis of the energy (angle-averaged) particle distribution.

To demonstrate these effects we use very simple examples of current sheets described via the invariants-of-motion method [2]. We show that for the wide intervals of observation angle the power-law spectra and, in particular, the positions and number of spectral breaks may be essentially different for the cases of the self-consistent and not-self-consistent magnetic fields in current structures responsible for the synchrotron radiation of the ensembles of relativistic particles with the multi-power-law energy distributions.

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Major radio flaring episodes of microquasar Cygnus X-3

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Cygnus X-3 is the brightest radio transient in our Galaxy producing occasionally major radio flares that can reach 20 Jy. The nature of source is a puzzle, but recent multiwavelength studies are converging into the source being a binary star containing a low-mass black hole and a Wolf-Rayet star. This makes Cygnus X-3 one of the promising progenitors of a gravitational wave source in our Galaxy. The unique source properties are likely due to the interaction of the compact object with the heavy stellar wind of the Wolf-Rayet star. In this presentation, I will go through results obtained in recent multiwavelength observing campaigns from Cygnus X-3 during major radio flare episodes. Motivated by the observational results, I will discuss a scenario in which the jet production is turned off or highly diminished before the major radio flare and the missing jet pressure allows the wind to refill the region close to the black hole. When the jet emerges again, it interacts with the dense stellar wind producing efficient dissipation of kinetic energy producing strong multiwavelength emission.

Spectra and variability of sources from the JVAS survey

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The results of observation in 2015, 2016 and 2017 of the sample of strong JVAS sources ($S_{8.4} > 0.5$ *Jy*) with flat spectra at Declination 10.5°÷18° (*J2000*) are presented. Observations were done at frequencies 2.3, 4.7, 8.2, 11.2 and 21.7 GHz. The integral spectra of all 45 sources are defined, objects with significant variability are allocated. For eight sources observed a week-long variability, four of which were discovered for the first time (characteristic time – 8÷35 days). Spectra of the variable components were determined.

Quasi-periodic pulsations of radio emission in solar flares

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Accelerated energetic particles during the solar flares produce various kinds of emissions at the multi-wavelengths, from radio waves to gamma rays. Detecting the emission in different wave ranges we are able to test processes taking place at the different height and having different origins. Frequently, we observe quasi-periodic pulsations (QPPs) in the flaring emission. The emission features can be caused by manifestations of the process of primary energy release or be the result of elections or wave propagation in the solar atmosphere. Evolution of the physical conditions in the flare source could result in deviations of the flare light curves from the harmonic shape. Such deviations are predicted by theoretic models of the QPPs which are based on MHD oscillations of plasma structures or on the auto-oscillations. Radio emission is a unique range for diagnostics of the flare source. In combination with emissions of other spectral ranges, we can use it as a good tool for diagnostics of both plasma parameters and flare processes. We will overview our technique and recent results of diagnostic of mechanisms of QPPs in the selected solar flares.

Methods of improving the prediction of solar flares in the microwave waveband

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Forecasts of flares in the solar active regions can be created on the basis of various parameters of the spots (square, geometrical configuration, intensity of radiation, spectra of sources and other), depending on the waveband of observations. A lot of information about the active region can be obtained from the radio range. This is for example an estimation of the photospheric magnetic field, a high-altitude structure above the active regions, a detailed analysis of the structure and dynamics of radio sources in the active region. One of the classical criteria for predicting flares in active regions in microwave band is the Tanaka-Enome [1] criterion. However, its effectiveness can vary from cycle to cycle and the structure of the active region. To evaluate the effectiveness of the original Tanaka-Enome criterion and modified Tanaka-Enome criteria [2] can be used long-term database of the microwave solar observations of the RATAN-600 [3]. This database is in an electronic form includes the time period from 1997 to the present, i.e. covers nearly two 11-year cycle of solar activity, allowing to analyze the efficiency criteria in predicting flares in solar active regions at short and long periods of time.

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Methodical results of RATAN-600 Sun observations in tracking (scanning) mode

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We report our work here on the setting up the Sun tracking (scanning) mode using a reduced aperture of the South + Periscope mirror system of the RATAN-600 radio telescope. In this mode, the observations of the Sun are performed by the feed mirror tracking, the feed mirror fast scanning, or slow scanning the primary feed carriage while tracking the Sun with the feed mirror. The main mirror shape is a parabolic cylinder with a 100 m aperture, or a circular cylinder of an optimal radius with a 120 m aperture.

We show that the Sun antenna temperature is decreased by 30 or 38% when an aperture width is 120 m or 100 m, in comparison with a full aperture mode, which is in agreement with our calculations. The field of view of the telescope with the main mirror shaped as a circular cylinder of an optimal radius is ±1.5º from the azimuth used for the antenna settings calculation, the Sun tracking (scanning) duration is 12 minutes for each of 15 azimuths, and a full tracking (scanning) time for the azimuths in the range of ±30º is over 3 hours a day, minus antenna setting time. In the reduced aperture mode, the Sun antenna temperature in increased by 5-10% while the level of the sidelobes is decreased in the azimuths far from the meridian with respect to the near ones, which is in agreement with our calculations as well. In the regular multi-azimuthal observations with a full aperture the Sun antenna temperature in the far azimuths falls by 10-15%, while the sidelobes grow, as expected.

We developed a model of the South + Periscope mirror system and calculated the antenna patterns in the tracking (scanning) mode, as well as the aberration curves of the system in different azimuths. For the antenna pattern calculations we employed a combination of the geometry optics with an aperture integration method, and more precise and versatile physical optics method using a fast multilevel algorithm [1]. We provide methodical results of the Sun observations in the tracking (scanning) mode, as well as the observations of the Moon and the Crab Nebula radio source using the Sun spectral-polarimetric receive complex in the frequency range of 3-18 GHz for two circular polarizations and the high sensitivity complex at the wavelengths 1 cm, 1.9 cm. 3.5 cm, and 6 cm.

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Fast Very High Energy γ-ray Flare from BL Lacertae during a Period of Multiwavelength activity in June 2015

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The mechanisms producing the fast variability of the γ-ray emission in active galactic nuclei is under debate. The MAGIC Telescopes detected a fast Very High Energy (VHE) γ-ray flare from BL Lacertae on 2015 June 15. The flare had a maximum flux of (1.5 ± 0.3) × 10 −10 photons cm −2 s −1 and halving time of 26 ± 8 minutes. The MAGIC observations were triggered by a high state in the optical and high energy (HE) γ-ray bands. In this paper we present the MAGIC VHE γ-ray data together with multiwavelength data from radio, optical, X-rays, and HE γ rays from 2015 May 1 to July 31. Well-sampled multiwavelength data allow us to study the variability in detail and compare it to the other epochs when fast VHE γ-ray flares have been detected from the source. Interestingly, we find that the behaviour in radio, optical, X-rays and HE γ-rays is very similar to other two observed VHE γ-ray flares. In particular, also during this flare there was an indication of rotation of the optical polarization angle and of activity at the 43 GHz core. These repeating patterns indicate a connection between the three events. In this talk I discuss these results in detail.

On the positive spectral slope of solar flare mm emission observed with RT-7.5 radio telescope: simulation and interpretation

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The growing **emission** spectral flux between 93 and 140 GHz **revealed** for the solar flares 4 July 2012, 5 July 2012 and 2 April 2017 with the Bauman Moscow State Technical University Radio Telescope RT-7.5 is analyzed. Simultaneous radio, ultraviolet and X-ray observations have shown that time profiles of 93 and 140 GHz emissions correlate with soft X-ray emission for the 2 April 2017 solar flare and with centimeter and hard X-ray ones for 4 and 5 July 2012 events. This suggests the different nature of millimeter emission from different flares. The differential emission measure of coronal plasma in the temperature range of 0.3-20 MK based on SDO/AIA ultraviolet observations has been found. The contribution of this plasma to the millimeter emission turned out to be negligibly small for all flares. Several models of flaring millimeter emission, including thermal/non-thermal radiation from the chromospheric region, involving free-free and gyrosynchrotron mechanisms have been considered.

Electron beam and plasma at the looptop of solar flare of 2017-09-10 15:52 X8.2

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The solar flare of 2017-09-10 15:52:00 (GOES X8.2) is considered. The RHESSI spectrometer [1] registered a single coronal local source of hard X-ray (HXR).

The HXR source was moving radially during 20 minutes for 20 arcseconds distance. The HXR energy spectra were obtained. The spectrum of bremsstrahlung X-ray extends from energies 7 keV to 200 keV with break energy of 50 keV, spectral indices of the two-power-law spectrum at the maximum of HXR flux are 7, 3 consequentially.

The spectra of accelerated electrons were reconstructed by Tikhonov's regularization method [2] , and by forward-fitting of a thin target model. A hardness of energy spectra of accelerated electrons by these methods coincides. The size of a soft X-ray source of ~ 12 arc seconds was obtained by RHESSI images. Using the values of the emission measure and the volume of the emitting source, a plasma density was estimated ~ 10^{11} cm^{-3} and plasma temperature was obtained 40 MK. The delay spectrum for the HXR time series of different energies has a decreasing shape that is atypical for the HXR looptop source [3]. The decreasing shape of time delays spectrum does not correspond to a trap plus precipitation model. Therefore, the peculiar magnetic field, the anisotropy in the distribution of accelerated electrons, and also the presence of turbulence are expected.

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Open database of solar flare events in 11.2 GHz

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The 1.8-meter solar radio telescope at Metsähovi Radio Observatory has been in nearly continuous operation for the last 17 years, interrupted only by service breaks, extremely bad weather and the sun's path overlapping with the geostationary orbit twice a year. Total solar flux at 11.2 GHz is logged at a 5 kHz sampling rate from the telescope's two outputs, linear and logarithmic. The produced time series and the telescope itself were shown to be reliable and to enable scientifically significant observations for solar activity and cyclicity studies when compared to similar datasets.[1] Solar radio bursts have been logged as well and the high sampling rate makes studying their fine structures possible.[2]

The need for an online database of detected burst events arises from their fairly large amount, the potential science that can be gained from them and from the principles of open data. A new detection algorithm has been developed based on robust curve fitting and outlier detection methods utilised by K. Vida and R.M. Roettenbacher with stellar flares in Kepler light curves.[3] More details about each flare will be reported, such as the peak strength, the duration and potential double- or triple-peaked structures. A connection to databases of X-ray flux is considered. The database aims for a user-friendly interface and an easy access to raw data.

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Directivity of solar type IV bursts

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Solar flares and coronal mass ejections (CMEs) are efficient particle accelerators and their processes can be observed in radio emission. Accelerated particles can either cause oscillations in the surrounding medium, creating Langmuir waves and hence radio emission at the local plasma frequency, or the trapped particles can gyrate along the magnetic field lines and emit synchrotron radiation. The two different emission mechanisms can be identified, for example, from their flux spectrum and frequency range.

Solar radio type IV bursts have been associated with moving magnetic structures that contain trapped particles. These structures can be expanding flare loops low in the atmosphere, or rising and propagating CME loops higher in the corona. Frequency-drifting radio emission reveals the movement of the source, as the plasma frequency decreases when the transient is moving outward from the Sun to the lower density plasma. The sources of type IV bursts are sometimes complicated to identify, as the emission can contain both plasma and synchrotron emission. At decimeter-meter waves (ground-based observations) and at decameter-hectometer waves (observations from space, above the Earth atmospheric cut-off) there are also very limited possibilities for imaging.

Type IV bursts have been known to show directivity effects and simultaneous observations with Wind, STEREO A, and STEREO B spacecraft have recently confirmed this. Strong type IV radio emission is typically observed when a fast, halo-type CME is propagating towards the observer. Our recent analysis of interplanetary type IV bursts shows that EUV waves were observed in all events and that intense and compact type IV bursts were observed only when the EUV wave propagated globally across the whole visible disk. This may simply indicate the propagation direction of the depleted CME material, if not the directivity of the type IV radio emission as suggested in earlier works. In addition to this, or alternatively, it is possible that at least part of the type IV emission can be absorbed toward certain viewing angles. We present examples of such events and discuss alternative interpretations for the observed directivity.

Polarized emission properties of active galactic nuclei jets

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We used 15 GHz multi-epoch VLBA polarization sensitive observations of more than 400 sources within a time interval 1996-2016 from the MOJAVE program, and also from the NRAO data archive. We have analyzed the linear polarization characteristics of regions downstream of the compact core feature, and their changes along and across the parsec-scale AGN jets. We have detected significant increase of fractional polarization with distance from the core along the jet as well as towards the jet edges suggesting increase of a regularity of the magnetic field. We also discuss orientation of the electric vector position angle with respect to the local jet direction for the sources of different optical classification.

Oscillatory properties of the solar small-scale magnetic structures

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The oscillatory properties of the long-lived small-scale structures were investigated in this work. Long-period quasi harmonic oscillations (with periods in the interval from 30 to 300 minutes) of the structures as a whole were detected on the different levels of the solar atmosphere. These results have been obtained on the data sets taken from the different instruments on the board of SDO satellite. Except for this, we have studied the relationships between the magnetic field, the lifetime and the period of these oscillations.

Another goal of this work is to perform the detailed analysis of the structural and the temporal evolution of the small-scale magnetic structures and derive some conclusions about their physical nature.

The statistical method of the regression analysis and the Fourier Wavelet transform were used to obtain the results.

Time-evolution of these structures was traced during their lifetime. Three different evolutionary phases were defined for each magnetic structure: the growth phase, the quasi stable phase and the phase of the destruction. Long-period oscillations obtained for the quasi stable phases could be considered as Eigen oscillations of a long-lived magnetic structure around the position of its stable equilibrium. Naturally, the values of these periods depend on magnetic fields strength of the structures. The oscillations, with the same periods, were also observed in the bright cromospheric formations associated with the photospheric small-scale magnetic structures. It suggests that in these cases we have a deal with the unified magnetic system - a vertical magnetic flux tube laterally compressed by horizontal flows at the junctions of super convection cells.

Molecular line observations of star forming regions

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Recent Planck and Herschel satellite projects have considerably improved our understanding of the star formation in the Milky Way. The all-sky maps from Planck mission revealed a multitude of dense and cold clumps, of which several have been mapped in higher resolution with the Herschel satellite and with the SCUBA-2 instrument at the James Clerk Maxwell telescope (JCMT). These observations provided a detailed picture of the density structures and morphology of the star forming regions. However, in order to study the kinematics and star formation activity within the clouds, molecular line observations at radio wavelengths are required.

The TOP (TRAO Observations of Planck cold clumps) project is a key science program at the Taeduk Radio Astronomy Observatory (TRAO). The aim of the project is to provide an unbiased 'all-sky' survey of 2000 Planck detected cold clumps, covering a wide range of evolutionary stages and Galactic environments. Related to the TOP project, other surveys and follow-up observations are being conducted at other mm and radio telescopes, Korean VLBI Network (KVN), Nobeyama Radio Observatory (NRO), Submillimeter Array (SMA), and JCMT. the key science goals of these surveys are to study the structure of the molecular clouds, the chemical and dynamical evolution of the molecular clouds, the role of filaments in the formation of dense clumps and star formation, and the kinematics of molecular clouds (rotation, outflows, infall).

In this presentation, I will briefly discuss the Planck and Herschel observations, and give and overview of the TOP project and the various follow-up observations related to the project. As an example, I will also introduce some of our latest results of combining the information from the Herschel and SCUBA-2 observations with the observations from the TOP project.

Zooming in the jet formation site in the nearby active galactic nuclei using RadioAstron

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During the past five years, RadioAstron Nearby AGN Key Science Program Team has carried out multiple space-VLBI imaging experiments on nearby radio galaxies M87, 3C84 and Cen A with an aim to study the structure of their radio jet formation sites. The obtained images significantly exceed the resolution achieved in ground-based experiments revealing new details of the jet formation site and of the interplay between the jet and the ambient medium. For example, in 3C84 we have detected a surprisingly wide edge-brightened jet merely a few hundred gravitational radii from the central engine, a "mini-cocoon" around the recently restarted parsec-scale jet, and high brightness temperatures that are at or above the inverse Compton catastrophe limit. Furthermore, we have been able resolve the internal structure of the jet acceleration and collimation zone in M87. I will give an overview of the results of the key science program.

Identification of quasi-transverse propagation effect for solar flare microwave emission

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Some solar flares demonstrate dominance of the ordinary mode over the extraordinary mode in the circularly polarized gyrosynchrotron emission at a frequency of 17 GHz and above [1,2]. There are three possible explanations of these observations: pitch-angle anisotropy of accelerated electrons, positrons generation during flare, or effect of quasi-transverse propagation (QTP-effect).

The main goal of our research is to develop methodology of identification of flare events with QTP-effect and to find flares which ordinary mode microwave emission could be explained only by QTP -effect. Flares with the ordinary mode of their emission at 17 GHz near center of the solar disc have been found in paper [1]. In the current analysis we have used data from NoRH, SDO/AIA, SDO/HMI and RHESSI instruments. Conclusions about the QTP -effect on microwave emission propagation were made after modeling of coronal magnetic field and flare loop microwave emission using the GX Simulator of the SolarSoftWare package. We have used linear and nonlinear force-free magnetic field extrapolations to create our models. This research continues our previous work [3], which was extended by taking into account data about full vector of photospheric magnetic field.

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Forecast of solar flares from observations in microwave at Kislovodsk station

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We analyzed the microwave radiation of the Sun observed on radio telescopes of the Kislovodsk astronomical station RT-3 (4.9 cm) and RT-2 (3.2 cm). Comparisons of long series of observations with observations on other radio instruments and also in the optical and X-ray ranges have been made.

A study is made of the forecast the flare activity using the data of the solar microwave radiation. To do this, we use the daily calibrated data of the radio observations of the Kislovodsk astronomical station 1962-2017. and also observations at the wave of 10.7 cm and X-rays. The reliability forecast of flare activity according to the Ermoshenko criterion [1] 80% and the Tanaka-Enome criterion [2] 85% were obtained. This reliability indicates the possibility of predicting the solar flare activity according to the microwave radiation.

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Observations of mm radio emission from M-class solar flares with RT-7.5 radio telescope

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Observations of three M-class solar flares obtained by the Bauman Moscow State Technical University Radio Telescope RT-7.5 at frequencies 93 and 140 GHz are presented [1]. The positive spectral slope was revealed at millimeter range for all flares. Microwave radio, ultraviolet and X-ray time profiles of the flare obtained by RSTN, SDO/AIA, GOES and RHESSI, were additionally analyzed to find the interpretation of the observed spectra.

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Model of solar faculae

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Solar facular nodes regarded as relatively stable and long-lived bright active formations with a diameter 3-8 Mm and having a fine (about 1 Mm or less) magnetic structure with magnetic field strengths from 250 G to 1000 G are modeled. The stationary MHD problem is solved and analytical formulae are derived to calculate the pressure, density, temperature, and Alfven Mach number in the configuration from the corresponding magnetic field structure. The facular node is introduced in a hydrostatic atmosphere defined by the model [1] and is surrounded by a weak (2G) external field corresponding to the global magnetic field on the solar surface. The calculated temperature profiles of the facular node at the level of the photosphere have a specific shape: the temperature on the facular axis is lower than that in the surroundings but in the nearest vicinities of the axis and at the periphery of the node, the gas is 200-100 K hotter than the surroundings. Here, on the level of photosphere, the model describes both the central darkening of the faculae (like Wilson depression in sunspots) and also ring, semi-ring and segmental facular brightening observed with New Swedish 1-m Telescope at high angular resolution [2]. In the temperature minimum region (z = 525 km), the central dip in T-profile disappears and the facula as a whole is hotter than the chromosphere. At all heights of the chromosphere the temperature of the faculae is higher than surrounding environment at the same level. This difference is particularly significant at heights of 1.5 and 2.2 Mm. Apparently, just at these layers the facular flux tube forms the bright phenomena which are designated by observers as flocculi or plages.

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Long-term study of the GPS objects in a wide frequency range

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Gigahertz-Peaked Spectrum (GPS) sources – compact extragalactic objects, presumably young predecessors of bright radio sources, are of interest as early stages of evolution of active nuclei of galaxies. The small linear dimensions of GPS underlie the assumptions about their youth. The study their radio properties gives information about the peculiarities of synchrotron radiation and how it arises and develops in extragalactic structures. The report will presents a multi-frequency study of GPS objects based on the ten-year measurements of the RATAN-600 radio telescope (1.1, 2.3, 4.8, 7.7, 11.2 and 21.7 GHz), data of low-frequency survey GLEAM (GaLactic and Extragalactic All-Sky Murchison Widefield Array Survey) and TGSS (Tata Institute for Fundamental Research GMRT Sky Survey), and high-frequency data of the mission Planck. The analysis of full spectra (0.7-857 GHz) revealed 164 GPS-candidate, which makes a small share of GPS in the initial sample-about 2%. Significant statistical difference of the radio properties of GPS, depending on the subclass AGNs and wide range of measured and estimated values indicates the heterogeneity of the sample and different conditions of the environment in which the non-thermal radiation is formed.

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Quiescent and Flaring Radio Emission from Brown Dwarfs

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Ultracool stars, the spectral class > M7, have low X-ray-radio luminosity ratio L_X/L_R ~ 10^12 Hz as compared to the other stars of late spectral classes (L_X/L_R ~ 10^15.5 Hz). One of the ultracool stars is the brown dwarf TVLM 513-46546 (M9) which reveals two components of the microwave radiation It is shown that gyrosynchrotron radiation from a system of magnetic loops quasi-uniformly distributed over the surface of a star can be the source of slowly varying or S-component of the radio emission of TVLM 513-46546. Properties of S-component make it possible to draw more definite conclusions about the parameters of the sources and the nature of their distribution in the brown dwarf corona.

The second completely polarized component with a high brightness temperature (≥ 10^11 K) and a narrow radiation pattern is interpreted usually in terms of electron cyclotron maser (ECM) emission. We propose the coherent plasma mechanism for intense highly-polarized radio emission from brown dwarfs. Dissipation of electric currents leads to heating of the plasma and to evaporation of a thin 'pressed-down' atmosphere. As a result, the condition $\omega_p > \omega_e$ at coronal levels required for the plasma mechanism of radio emission is fulfilled.

In addition, for energetic electrons, we suggest the acceleration mechanism based on electric current oscillations in a coronal loop, which can explain both long-lived quiescent and flaring radio emission from brown dwarfs.

Analysis of the properties of coronal holes in the 24-th cycle of activity

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The analysis of the properties of coronal holes in the 21-24's activity cycle is presented in this study. To select the CH in the 24th cycle, we have reconstructed the synoptic charts of the observational data obtained from the SDO / AIA-193Å instrument. In order to determine magnetic characteristics of a coronal hole, their positions were combined with the observations of the magnetograph WSO and the SDO. The boundaries of a coronal hole have been combined with the data of magnetic fields. In result, a number of data on the coronal holes for the Carrington rotation 2095-2205 was obtained. This series of date continues the series of the coronal holes, obtained earlier for the period 1975-2010 [1]. A comparative analysis of the properties of the coronal holes of the 24th cycle of activity with the data of 21-23 cycles is performed. The largest total coronal hole area was observed at the minimum of the 24-cycle activity. The minimum area of the coronal hole is observed at the activity maxima, and the area at the maximum of the 24th cycle is approximately equal to the coronal hole area at the maximum of the 23rd cycle. Also, we have made the comparison of the coronal hole properties observed in optic with the radio observations obtained for the total solar disk.

We have trained a neural network that accurately isolates CHs from SDO/AIA 193A solar disk images without additional complicated steps [2]. We compare results with publicly available catalogues of CHs and demonstrate stability of the neural network approach. In our opinion, this approach can outperform hand-engineered solar image analysis and will have a wide application to solar data. In particular, we investigate long-term variations of CH indices within the solar cycle 24 and observe increasing of CH areas in about three times from minimal values in the maximum of the solar cycle to maximal values during the declining phase of the solar cycle.

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Tilt of sunspot bipoles in 15-24 cycles of solar activity

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The latitudinal dependence of tilt angles of active regions and its change with solar cycle is investigated. We used digitized sunspot drawings with polarity and strength of magnetic field in sunspots cover the period from 1917–present. We identified bipolar groups and their tilt angles inside each active region. Was find that the latitudinal profile of tilts does not monotonically increase with latitude as most previous studies assumed [1, 2], but shows a clear maximum in mid-latitudes. We also find that latitudinal dependence of tilts varies from one solar cycle to the other, but larger tilts do not seem to result in stronger solar cycles. Finally, we also find the presence of a systematic offset (non-zero tilts at the equator) in tilt of active regions, with odd cycles exhibiting negative offset and even cycles showing the positive offset.

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New results of the long-time monitoring of microquasars

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We report on the radio properties of variable radio emission of bright microquasars, as determined from daily multi-frequency monitoring observations with the RATAN-600 radio telescope during 2010–2017: V404 Cyg, SS433, Cyg X-1, LS5039, GRS1915+105 and LSI+61◦303. We have detected many giant flares from SS433, when fluxes grew up in 2-3 times with optical thin non-thermal spectra. In the quiet states, lasting up to 200 days, we have detected a weak modulation with an orbital period of 13.1 days or with a nutation period of 6.3 days. We have observed V404 Cyg in June 2015 and have detected the bright flare (~4Jy) simultaneously with the huge X-ray flare (40 Crabs at 15–50 keV) on 26 June 2015. This flare had the characteristic synchrotron spectrum with a low-frequency turn-over. This is probably due to a synchrotron self-absorption or an absorption due to thermal electrons mixed with the relativistic ones [9]. During four days, the flaring flux decreased with time as a power-law ~t^(-1.5). We detected two giant radio flares of the X-ray binary microquasar Cyg X-3, consisting of a Wolf–Rayet star and probably a black hole. The first flare occurred on 13 September 2016, 2000 days after a previous giant flare in February 2011, as the RATAN-600 radio telescope daily monitoring showed. After 200 days on 1 April 2017, we detected a second giant flare. Both flare are very similar in temporal and spectral properties [2]. We have detected an active state of Cyg X-1 in 2016-2017. The periodic flares from LSI+61◦303 are dramatically changed during almost total super-orbital 4.6-year period (2013-2018). The high-mass microquasar XRB LS 5039, comprising the O6.5-type star and probably a black hole has been measured at 4.7 GHz. In 2017, we measured the average (over 10–15 days) flux density at 8.2 GHz at the level of 5–20 mJy; thus, the spectrum is non-thermal with spectral indices (here, always $S_\nu \propto \nu^\alpha$) between − 0.5 and − 1.2, with the median value of − 0.7. In March 2018 we began multi-frequency monitoring of the recently detected microquasar MAXI J1820+070. Its spectrum is stable flat (2.3-11.2 GHz) during a slow decay of the flaring event. We describe the properties of massive ejections based on multi-band (radio, X-ray and γ-ray) studies. The general properties of the light curves are closely connected with the processes of jet formation in microquasars.

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The first experience of the FRB search with RATAN-600 at 4.7 GHz

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We are carring out the search program of the mysterious and rare fast radio bursts (FRB) [1] with the RATAN-600 radio telescope. Daily during nine months and 24 hours we use separate antenna, the Western Sector and secondary mirror (SM) with new design. Its effective area is near 1100 meter in square at elevation h=52deg (Dec=33d08). The special three high sensitivity receivers at 4.7 GHz established in the focal plane of SM. The total frequency band of 600 MHz of each receiver was divided by the microwave filters on four sub-bands of 150 MHz and all signals of 16 channels of back-end are recorded with the maximal temporal resolution 0.5 ms. The special routine on the powerful PC analyzes the coming signals in order to find the fast bursts (5 sigma = ~3-5 Jy), shifted in time due to the interstellar (or intergalactic) dispersion (DM ~ 100-1500 pc/cm^3) in dependence on the sub-band frequencies. events with expected fluxes 1-30 Jy and error box of coordinates will be send to the robotic optical wide-angular small telescopes array constructing. The relatively big field of view of the three-beam system in the 24-hours survey allows to detect three FRB per year. In 2017-18 we have carried out the pilot observations of the bright and close pulsar PSR B0329+54 at 2.3 and 4.7 GHz with wide-band (120 and 600 MHz respectively). We have detected the 10-30 pulses with the own spin period P=0.71452s getting in the antenna beams, recorded with time interval 0.5ms. The width of the average pulse is equal to W50=10 ms at 4.7 GHz. Such measurements are a well test for the FRB searches. So far we have not detected the the dispersed pulses. We see that the most suitable time is the night hours with almost total absence of the interference. We have detected a lot of usual discrete sources in the area of the survey when we summarized the sub-bands and daily records. We plan to change the elevation (from DEC = 33d08m to 22d01m) of the survey in May 2018 in order to improve the condition of the search.

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Results in the clustering analysis of radio peaked spectrum sources.

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Compact steep-spectrum sources (CSS), high frequency peakers (HFP), and gigahertz-peaked spectrum sources (GPS), hereafter grouped as Radio Peaked-Spectrum sources (RPS), are compact radio AGN with a characteristic convex spectrum[1]. Several studies have led to the hypothesis that free-to-free absorption (FFA)[2] in thermal plasma or synchrotron self-absorption (SSA) [3] are the main physical processes responsible of the convex emission. Unfortunately, the observational data that supports the studies of the properties and dynamics of RPS sources have been found contaminated by blazars in active states[4,5,6]. In this talk I present the main results of a clustering analysis of 464 sources candidates to be RPS sources. The cluster analysis is performed using Multi-dimensional Scaling (MDS) and t-distributed Stochastic Neighbour Embedding (t-SNE) neural networks. From those analyses, we were unable to find a clear classification for RPS galaxies. Moreover, we find that few sources that are studied for long periods of time remain as RPS sources. Those findings compromises several of the assumptions that we have about those AGN.

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Constancy of the coronal magnetic loop cross section

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Coronal magnetic loop observations give evidence that the solar magnetic loop cross section is constant along all length.[1] This is interesting, because coronal magnetic loop length can reach several height scales of the inhomogeneous atmosphere and therefore pressure may vary over the order of magnitude at different heights in a magnetic loop. A force balance in the stationary current-carrying magnetic loop is considered. The hydrostatic equation of the force balance is solved under the conditions of constant longitudinal electric current and the conservation of the longitudinal magnetic field flux. As a result, dependence of the magnetic loop radius on height in case of different plasma beta values in the magnetic loop footpoint is obtained. It is shown, that when gas-kinetic pressure inside the loop is small in comparison with the longitudinal magnetic field pressure, then the thickness of the loop is constant in the corona that is typical for the majority of the observed coronal magnetic loops.

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Quasi-periodic oscillations of the small-scale magnetic structures and specific method of measurement of the differential rotation of the Sun

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The data of the SDO/HMI with an angular resolution of 1 arcsecond were used to explore the differential rotation on the Sun using an original "p2p" effect on the base of oscillations of small-scale magnetic structures in facular regions [1]. The curve of the differential rotation obtained with the specific method on the base of SDO/HMI data coincides well with the curves, obtained earlier by the ground-based observations.

Research of the quasi-periodic oscillations of the various structures on the Sun in the active areas and outside of them plays an important role in the studying of the different physical parameters of the solar atmosphere.

There are well-known oscillations in the Sun with a period of 3-10 minutes, which can be interpreted as a propagation of acoustic and MHD-waves along the flux tubes of active solar formations. Besides, the oscillations with periods of 20-40 minutes and even of few hours were reliably detected in power spectra of solar magnetic elements.

It is known that the regular periodic processes give us a good standard of time. A regular process is not only harmonic oscillations but also any process in which the spectrum of the fundamental mode is clearly defined and stable. One of such processes, named as "p2p" effect, takes place in all observations when the discrete detectors, as a CCD, are used. In particular, this effect manifests itself in the observational data of the SDO/HMI (SDO - Solar Dynamics Observatory, HMI - Helioseismic and Magnetic Imager). It is a parasitic effect in nature, i.e. an artifact, but it has a stable character, and we can use this artifact as an effective tool for the studying of different temporal processes of solar physics. We put this artifact in the basis of the method for determining the velocity of the traces on the Sun surface.

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