Abstracts for Monday 26th May

MHD oscillations in solar flares

Dr Tom Van Doorsselaere, KU Leuven

Solar flares are the most energetic events in the solar system, but we do not understand their physics very well. Often periodic intensity variations are observed during solar flares. Some of these can be interpreted as MHD oscillations of post-flare loops, or neighbouring loops. I will give an overview of recent observational results on flare oscillations. I will discuss the common models for these oscillations. I will explain how these oscillations can be used for MHD seismology of solar flares, and how this will allow us to gain a better understanding of the solar flare surroundings.

Some unusual phenomena in solar flare events

Prof Alexandr Solo'ev, Central (Pulkovo) astronomical observatory

We present a number of flare events when a remarcable phenomena as, for example, the suction of cold chromospheric plasma along the helical trajectories into the extremely hot energy-release region of the flare, have been observed. The possible theoretical interpretation of these phenomena is discussed.

Fast magnetoacoustic wave trains in magnetic structures of the solar corona

Dr David Pascoe, University of Warwick

Fast magnetoacoustic waves are highly dispersive in waveguides and so can generate quasi-periodic wave trains if a localised, impulsive driver is applied, such as flaring energy release. Wave trains have been observed propagating in the solar corona and may be of use as a seismological tool since they depend

upon the plasma structuring perpendicular to the direction of propagation. We extend existing models of magnetoacoustic waveguides to consider the behaviour for expanding magnetic funnels, coronal holes, and active regions. We investigate the dependence of the wave train properties on variables such as the density contrast ratio, density stratification, and the spectral profile of the driver. More realistic geometries lead to novel wave behaviour, such as the formation of additional wave trains that propagate outside but along the density structure due to leakage and refraction. The results of our numerical simulations demonstrate properties similar to those of wave trains observed in the solar corona. We consider in detail the case of a high quality quasi-periodic propagating wave train recently observed with SDO/AIA.

The measurement of emission formation heights in the sunspot umbrae atmosphere for several wavelengths in uv and euv band.

Miss Anastasiia Deres, ISTP

The study of MHD oscillations and waves in the solar atmosphere is an important part of the solar physics. They are natural probes containing information about physical medium, where they propagate. In this report we present the analysis of 3-minutes oscillations observed with Solar Dynamics Observatory in different active regions: NOAA 11131, NOAA 11582, NOAA 11711. We investigated delays between oscillations detected at different wavelengths, such as 1700, 1600, 171, 193 and 304 √Ö, over the sunspot umbrae. Each wavelength corresponds to a layer in the sunspot atmosphere with certain temperature. The relative position of the emission formation layers was revealed. The order of layers was found to be the same for all examined active regions. The lowest layer corresponds to 1700 Angstrom wavelength, then 1600, 304, 193, and 171 Angstrom layers. We also estimated the distance between different layers. The results obtained were compared with two models of the sunspot umbrae atmosphere (Fontenla et al, 2009, Maltby et al, 1986). We concluded that the modern model (Fontenla et al, 2009) is more realistic according our measurements.

Diagnostic of MHD Waves in the Neighbourhood of Coronal Null Points

Miss Sandra Milena Conde Cuellar, National Institute for Space Research (INPE)

The MHD waves are assumed to be an important source of heat input in different regions of the solar corona. In particular, MHD waves may be responsible by the presence of higher outflow speeds in the neighbourhood of coronal null points (Petschek 1964, Bulanov and Syrovatskii 1980). Also, the energy dissipated by damping MHD waves is an important heat source in other processes occurred close to the coronal null points (McLaughlin, Hood and DeMoortel 2012). However, to find a clear observational evidence of MHD waves is not an easy task. In the present work are analysed different active regions, where has occurred magnetic reconnection. In these regions are searched waves through the Pixelised Wavelet Filtering technique, just before and after a solar flare has occurred. The data cubes (2D) analysed are obtained in the EUV band from the TRACE and SDO data catalog.

Using X-ray Observations to Diagnose Solar Flares

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X-ray observations of solar flares are conducted for almost 70 years. Many observations have been gathered through this time and raised our knowledge about the most energetic solar emission. The X-ray emission sources are mostly observed during solar flares, and give us an information about hottest thermal parts of flares as well as non-thermal processes connected with acceleration and propagation of high energy particles. The thermal emission sources are observed as loop-top sources (LTS) which were discovered by instruments installed onboard Skylab space station. LTSs are filled with hot (>10 MK) and relatively dense plasma (10^10-10^11 cm^-3), and they are observed high in the solar corona. The most fruitful analysis of LTS may be performed in a case of Long Duration Events (LDE) which are solar flares last up to several dozen hours. Present X-ray instruments, e.g. RHESSI, allow for simultaneous imaging and spectroscopy giving opportunity for detailed investigation of the physical nature of LTSs. The observations show that continuous heating is needed to explain such a long existence of LTS. The LTS heating mechanism is still not well understand and their physical nature is unclear. The other type of X-ray thermal emission is observed in foot points as impulsive brightenings visible during impulsive phase. These structures, discovered by Yohkoh/SXT, are co-spatial with non-thermal emission produced by high-energy electrons bombarding the chromosphere. Non-thermal X-ray foot point sources observed by RHESSI give

ample information about the physics of dense parts of solar atmosphere heated by non-thermal electrons. Moreover, such observations allow to estimate the non-thermal electrons spectra which thus may be used for estimation of the nature of reconnection region. This region may be also, more directly, investigated through X-ray observations of flares coronal sources when foot points are occulted by a solar limb, and non-thermal emission from corona is not masked by stronger foot point sources. The X-rays have potential to give us extremely valuable information about the real nature of solar flares. We should be able to gather more valuable data in a future with STIX which is very sophisticated instrument that will be installed onboard Solar Orbiter mission.

On energy release during the flat, gradual phase of faint solar flares

Dr Larisa Kashapova, Institute of Solar-Terrestrial Physics SB RAS

We present results of study and discussion of problems concerning the processes of the energy release and transport during gradual phases of solar flares. The most well-known object of gradual phase investigation is long-duration events (LDEs). They are characterized by emission of the anomalously long-lived hot coronal plasma during several hours after the impulse phase. Observed phenomena could be either a result of a significant suppression of the thermal conductivity or a continuous energy input. Also, it could be a combination of both mechanisms. We found two C-class flares that showed an extraordinary long flat emission in the X-ray flux curves in the 3-12 keV energy band. The ""flat emission"" period was also observed at EUV and microwaves. The quasi-periodic pulsations were detected in the evolution of the electron temperature. Analysis of the oscillations in microwave and ultraviolet emission during the 7 June 2012 flare supports hypothesis that the wave energy, coming from the sunspot to the flare site, can keep up the plasma emission by suppressing the plasma thermal conductivity. The preliminary analysis of the 21 July 2013 flare are presented. The results of both analyses are discussed from the point of view of different mechanisms explaining LDEs and the role of wave energy in them.

Low amplitude decay-less kink oscillations, a common phenomenon in the solar corona?

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We investigate the new type of coronal oscillations recently discovered in SDO/AIA data. Opposite to flare induced decaying oscillations this type of transverse oscillations is not connected to any external impulsive impact like a flare or CME and does not show any significant decay. However they have very low displacement amplitude (lower than1 Mm). Therefore it is hard to visually identify them on movies. The oscillation period is different for different loops and was found to strongly depend on the loop length .The spatial structure of the phase of the oscillations corresponds to the fundamental standing kink mode.

The aim of this research was to estimate the prevalence of this phenomenon. We analysed 20 active regions (NOAA 11637-11656) observed in January 2013. For each active region we inspected 6 hours of observations at 171√Ö wavelength obtained with SDO/AIA. The oscillatory patterns on time-distance plots were visually identified and the oscillation periods were measured. The low amplitude decay-less kink oscillations are found to be present in the majority of analysed active regions. We did not identify any oscillation patterns only in a few small and undeveloped active regions. That means that this type of coronal oscillations is a common phenomenon in the corona and is a promising tool for coronal seismology.

Quasi-periodic Pulsations at Multi-wavelength in a Flare

Dr Jing Huang, National Astronomical Observatories, Chinese Academy of Sciences

Spatially resolved minute periodicities in flaring microwave emission of the flare on May 14, 2013

Dr Elena Kupriyanova, Pulkovo Observatory

Spatially resolved quasi-periodic pulsations (QPPs) with minute periodicities in microwave emission during solar flare on May 14, 2013 are studied. Data of Nobeyama Radioheliograph (NoRH) and Radio Polarimeters (NoRP) at 17 GHz and 34 GHz are used. Metods of correlation, Fourier and wavelet analyses are applied to time profiles of the microwave fluxes. The following interesting properties of QPPs have been found. The QPPs with the same period of 50 s originate from two different flaring loops of different sizes during the impulsive phase of the flare. Moreover, the larger loop has lower brightness than the smaller one. Another interesting property is that the QPPs of the flux integrated

over the first loop are in antiphase with the QPPs from the second loop. Such contradictory properties can not be in correspondence with properties of the standing slow magnetoacoustic waves trapped in magnetic loops of different sizes. Possible origin of the QPPs properties are disscussed.

Modulation of flare microwave emission by sausage mode

Dr Veronika Reznikova, KU Leuven Belgium

The modulation of the GS emission by fast sausage MHD oscillations was modeled for typical flaring parameters. For the first time a 3D model was adapted for this purpose and variations of the angle between the magnetic field vector and the line-of-sight have been taken into account. The variation of the thermodynamic quantities are found by linearizing the perturbed ideal MHD equations about the magnetostatic equilibrium. Effects of line-of-sight angle and instrumental resolution on perturbations of gyrosynchrotron intensity are analyzed for two models: the base model with the strong Razin suppression and the low density model in which the Razin effect was inessential at all examined frequencies. Results obtained for phase relations between low (f < fpeak) and high (f > fpeak) frequency emission oscillation contradict to previous predictions made with models without spatial resolution and assuming inhomogeneous emitting source.

Collapsing Magnetic Trap: Properties of Gyrosynchrotron Emission

Dr Victor Melnikov, Pulkovo Observatory

Dynamics of various parameters of nonthermal electrons injected into a collapsing magnetic trap has been considered. The electron energy and pitch angle non-stationary spatial distributions in an extensive inhomogeneous magnetic trap have been obtained by numerically solving the non-stationary Fokker,ÄìPlanck kinetic equation. It is shown that the high energy electrons are effectively accumulated and accelerated at the top of the collapsing trap due to the first order Fermi and betatron acceleration mechanisms. Spatial properties of gyrosynchrotron emission characteristics have been calculated for the obtained electron distributions. Specifically, the obtained solutions make it

possible to explain the radio brightness peak that is frequently observed at the top of solar flare loops (Melnikov et al., ApJL 2002; Reznikova et al., ApJ 2009).

Dynamics of Microwave Flare Loop observed by Nobeyama Radioheliograph

Dr Sujin Kim, Korea Astronomy

We have investigated a microwave flare loop observed at two frequencies of 17 and 34 GHz of Nobeyama Radioheliograph (NoRH). NoRH imaging data gives opportunity to investigated nonthremal particle dynamics through the capture of gyrosynchrotron emission with high spatial resolution of 10" at 17 GHz and 5" at 34 GHz. The flare occurred near the limb in 2014 October 28. The time profile of microwave flux showed several peaks and these peaks are divided with a strength of the flux into two groups; first three peaks were weak around 1000 sfu and later two major peaks were up to 3000 sfu. We examined the distribution of brightness temperature (Tb) of the microwave flare loop during impulsive phase, peak, and decay phase of each peaks. For this, we have mainly used 34 GHz data because it provides two times better spatial resolution than 17 GHz. Interestingly, the first group exhibits the maximum Tb at loop-top region throughout, while the maximum Tb of the second group appears at northern footpoint during impulsive phase and peak time and then moves to loop-top during the decay phase. We have derived a microwave spectral index in loop-top and northern foopoint of microwave flare loop. Based on the results, we will discuss the dynamics of nonthermal particles within the flare loops and what causes the difference of Tb distribution between two groups.