evolution of the tilted gas disk.

[구 IM-11] The centroid shift of Sgr A*

Il-Je Cho[1,2], Bong Won Sohn[1,2], Taehyun Jung[1,2], Motoki Kino[1], Guang-Yao Zhao[1], Ivan Agudo[3], Maria Rioja[4], Richard Dodson[4]
[1]*Korea Astronomy and Space science Institute (KASI),*
[2]*University of Science and Technology (UST),*
[3]*Instituto de Astrofisica de Andaluica (CSIC),*
[4]*International Centre for Radio Astronomy Research (ICRAR)*

The Galactic center, Sagittarius A* (Sgr A*), is the closest supermassive black hole and emits synchrotron radiation. It provides great opportunity to study the origin of mm/sub-mm emission. Currently, two competing models have been suggested as a jet base and a radiatively inecient accretion flow (RIAF). To unveil the properties, the extremely high resolution(~10μas) corresponding to the projected Schwarzschild radius of ~0.1AU is necessary. With KVN, a jet model can be tested by multi- frequency simultaneous observations because the optically thick surface in a jet (i.e. radio core) moves toward the center at a higher frequency. We conducted 8 observations with KVN at 43/86GHz in 2015, and found that the measured positional shift to the reference calibrator, J1744-3116, was ~0.3 mas to the south of Sgr A* using the source frequency phase referencing (SFPR) at Q/W bands for the first time. With the result, in the future, we will attempt to measure the variation of source position shifts that can constrain the direction of approaching jets and the variability of black hole activity of Sgr A*.

태양 및 우주환경

[박 SS-01] Statistical Studies on the Physical Parameters and Oscillations of Sunspots and Flares

Il-Hyun Cho[1], Kyung-Suk Cho[2,3], Yeon-Han Kim[2,3]
[1]*Kyung Hee University,* [2]*University of Science and Technology,* [3]*Korea Astronomy and Space Science Institute*

We perform three statistical studies on the physical properties and oscillations in the confined plasma such as a photospheric sunspot and confined coronal loop. From the statistical studies on the sunspot umbra and its oscillation, we find that (1) the total magnetic flux inside the umbra for the three groups increases proportionally with the powers of the umbral area and the power indices in the three groups significantly differ from each other; (2) the three groups have different characteristics in their umbral area, intensity, magnetic field strength, and Doppler velocity as well as their relationships; (3) the mean frequency of the umbral oscillations increases with the umbral mean magnetic field strength and height; (4) the time delay of the core intensity of Fe I absorption line relative to the continuum which are de-convolved with the frequency range higher than 3.5 mHz is mostly positive, implying that the photospheric umbral oscillations are likely upwardly propagating; (5) the umbral mean plasma beta ranges approximately 0.6-1.1 and does not vary significantly from pores to mature sunspots. From the comparative study on the quasi-periodic pulsations (QPPs) in the solar and stellar flares, (6) we find that the power index of the periods scaling the damping times observed in the stellar QPPs is consistent with that observed in the solar QPPs, suggesting that physical mechanisms responsible for the stellar QPPs are likely the magneto-hydrodynamic oscillation of solar coronal loops.

[구 SS-02] Anatomy of a flare-producing current layer dynamically formed in a coronal magnetic structure

Tetsuya Magara
School of Space Research, Kyung Hee University, Yongin, Korea

No matter how intense magnetic flux it contains, a coronal magnetic structure has little free magnetic energy when a composing magnetic field is close to a potential field, or current-free field where no volume electric current flows. What kind of electric current system is developed is therefore a key to evaluating the activity of a coronal magnetic structure. Since the corona is a highly conductive medium, a coronal electric current tends to survive without being dissipated, so the free magnetic energy provided by a coronal electric current is normally hard to release in the corona. This work aims at clarifying how a coronal electric current system is structurally developed into a system responsible for producing a flare. Toward this end, we perform diffusive MHD simulations for the emergence of a magnetic flux tube with different twist applied to it, and go

through the process of structuring a coronal electric current in a twisted flux tube emerging to form a coronal magnetic structure. Interestingly, when a strongly twisted flux tube emerges, there spontaneously forms a structure inside the flux tube, where a coronal electric current changes flow pattern from field-aligned dominant to cross-field dominant. We demonstrate that this structure plays a key role in releasing free magnetic energy via rapid dissipation of a coronal electric current, thereby producing a flare.

[구 SS-03] Formation of a large-scale quasi-circular flare ribbon enclosing three-ribbon through two-step eruptive flares

Eun-Kyung. Lim[1], Vasyl Yurchyshyn[1,2], Pankaj Kumar[1], Kyuhyoun Cho[3], Sujin Kim[1] and Kyung-Suk Cho[1]
[1]KASI, [2]BBSO, [3]SNU

The formation process and the dynamical properties of a large-scale quasi-circular flare ribbon were investigated using the SDO AIA and HMI data along with data from RHESSI and SOT. Within one hour time interval, two subsequent M-class flares were detected from the NOAA 12371 that had a βγδ configuration with one bipolar sunspot group in the east and one unipolar spot in the west embedded in a decayed magnetic field. Earlier M2.0 flare was associated with a coronal loop eruption, and a two-ribbon structure formed within the bipolar sunspot group. On the other hand, the later M2.6 flare was associated with a halo CME, and a quasi-circular ribbon developed encircling the full active region. The observed quasi-circular ribbon was strikingly large in size spanning 650" in north-south and 500" in east-west direction. It showed the well-known sequential brightening in the clockwise direction during the decay phase of the M2.6 flare at the estimated speed of 160.7 km s-1. The quasi-circular ribbon also showed the radial expansion, especially in the southern part. Interestingly, at the time of the later M2.6 flare, the third flare ribbon parallel to the early two-ribbon structure also developed near the unipolar sunspot, then showed a typical separation in pair with the eastern most ribbon of the early two ribbons. The potential field reconstruction based on the PFSS model showed a fan shaped magnetic configuration including fan-like field lines stemming from the unipolar spot and fanning out toward the background decayed field. This large-scale fan-like field overarched full active region, and the footpoints of fan-like field lines were co-spatial with the observed quasi-circular ribbon. From the NLFF magnetic field reconstruction, we confirmed the existence of a twisted flux rope structure in the bipolar spot group before the first M2.0 flare. Hard X-ray emission signatures were detected at the site of twisted flux rope during the pre-flare phase of the M2.0 flare. Based on the analysis of both two-ribbon structure and quasi-circular ribbon, we suggest that a tether-cutting reconnection between sheared arcade overarching the twisted flux rope embedded in a fan-like magnetic field may have triggered the first M2.0 flare, then secondary M2.6 flare was introduced by the fan-spine reconnection because of the interaction between the expanding field and the nearby quasi-null and formed the observed large-scale quasi-circular flare ribbon.

[구 SS-04] Electrostatic upper-hybrid waves and energetic electrons in the Earth's radiation belt

Junga Hwang[1,2], Dae-Kyu. Shin[1,3], Peter. H. Yoon[4,5], William. S. Kurth[6], and Dae-Young. Lee[3]
[1]Korea Astronomy and Space Science Institute, Daejeon 305-348, Korea, [2]Korea University of Science and Technology, Daejeon, Korea, [3]Chungbuk National University, Cheongju, Korea, [4]Institute for Physical Science and Technology, University of Maryland, College Park, MD 20742, [5][Also at] School of Space Research, Kyung Hee University, Yongin-Si, Gyeonggi-Do, 446-701, Korea, [6]University of Iowa, Iowa City, IA 52242

Electrostatic fluctuations near upper-hybrid frequency, which are sometimes accompanied by multiple-harmonic electron cyclotron frequency bands above and below the upper-hybrid frequency, are common occurrences in the Earth's radiation belt, as revealed through the twin Van Allen Probe spacecraft. In the literature upper-hybrid emissions are used for estimating the background electron density, which in turn can be used to determine the plasmapause locations, but the role of energetic electrons in generating such fluctuations has not been discussed. The present paper carries out detailed analyses of data from the Waves instrument, which is part of the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) suite onboard the Van Allen Probes. Combined with theoretical calculation, it is demonstrated that the peak intensity associated with the upper-hybrid fluctuations is