고에너지천문학/이론천문학

[구 HT-01] Morphology of radio relics in galaxy clusters

Paola Domínguez Fernández
UNIST

Galaxy clusters host Mpc-scale diffuse radio emission giving us evidence of large-scale magnetic fields in the Universe. It is relevant to understand magnetic field amplification processes occurring at the center and outskirts of galaxy clusters. Each of these processes are believed to give rise to observed radio haloes and radio relics, respectively. In this work, we focus on studying the continuum and polarised emission in radio relics. We use threedimensional

magnetohydrodynamical simulations of merger shock waves propagating through a magnetized, turbulent intracluster medium. Our model includes the diffusive shock acceleration (DSA) of cosmic ray electrons, their spatial advection and energy losses at run-time. We discuss the relation between the mock observation features and the underlying morphology of the magnetic field.

[구 HT-02] A PIC Simulation Study for Electron Preacceleration at Weak Quasi-Perpendicular Galaxy Cluster Shocks

Ji-Hoon Ha[1], Sunjung Kim[1], Dongsu Ryu[1] and Hyesung Kang[2]
[1]*Department of Physics, School of Natural Sciences UNIST, Ulsan 44919, Korea*
[2]*Department of Earth Sciences, Pusan National University, Busan 46241, Korea*

In the outskirts of galaxy clusters, weak shocks with $M_s < \sim 3$ appear as radio relics where the synchrotron radiation is emitted from cosmic-ray (CR) electrons. To understand the production of CR electrons through the so-called diffusive shock acceleration (DSA), the electron injection into the DSA process at shocks in the hot intracluster medium (ICM) has to be described. However, the injection remains as an unsolved, outstanding problem. To explore this problem, 2D Particle-in-Cell (PIC) simulations were performed. In this talk, we present the electron preacceleration mechanism mediated by multi-scale plasma waves in the shock transition zone. In particular, we find that the electron preacceleration is effective only in the supercritical shocks, which have the sonic Mach number $M_s > M_{crit} \approx 2.3$ in the high-beta (β~100) plasma of the ICM, because the Alfven ion cyclotron instability operates and hence multi-scale plasma waves are induced only in such supercritical shocks. Our findings will help to understand the nature of radio relics in galaxy clusters.

[구 HT-03] Structures and Energetics of Flows in Ultra-relativistic Jets

Jeongbhin Seo[1], Hyesung Kang[1], Dongsu Ryu[2]
[1]*Pusan National University,*
[2]*Ulsan Institute of Science and Technology*

We study ultra-relativistic jets on several tens kpc scales through three-dimensional relativistic hydrodynamic (RHD) simulations using a new RHD code based on the weighted essentially non-oscillatory (WENO) scheme. Utilizing the high-resolution and high-accuracy capabilities of the new code, we especially explore the structures and energetics of nonlinear flows, such as shocks, turbulence, velocity shear in different parts of jets. We find that the mildly relativistic shocks which form in the jet backflow are most effective for the shock dissipation of the jet energy, while the turbulent dissipation is largest either in the backflow or in the shocked ICM, depending on the jet parameter. The velocity shear is strongest across the jet flow to the cocoon boundary. Our results should have important implications for the studies of high-energy cosmic-ray production in radio galaxies.

[구 HT-04] Spectral variability of Blazar 3C 279 during 2009-2018

Sungmin Yoo and Hongjun An
Department of Astronomy and Space Sciences, Chungbuk National University, Republic of Korea

블레이자는 제트가 관측자 시선방향과 나란하게 놓여있는 활동은하핵(AGN)으로 모든 파장대역에서 변광을 보이는 것이 주요 특징이다. 우리는 블레이자의 변광특성을 이해하기 위해 강한 변광을 보이는 천체인 3C 279를 연구대상으로 선정했고, 9년간의 X선 및 광학 데이터를 이용하여 이 천체의 광도와 스펙트럼 기울기 사이의 상관관계분석을 수행하였다. 이를 통하여, 시간에 따라 상관계수가 변한다는 것과 X선 변광이 광학변광보다 65일 앞선다는 것을 발견하였다. 이 발표에서는 one-zone SED 모형을 이용해 위의 현상들을 해석한 결과를 제시한다.

[석 HT-05] X-ray orbital light curve modelling of HESS J0632+057 using intrabinary shock model

Jinyoung Kim and Hongjun An
Department of Astronomy and Space Sciences, Chungbuk National University, Republic of Korea

Gamma-ray binaries는 밀집성(중성자별과 블랙홀)과 질량이 큰 동반성 (>20 Msun)이 서로 공전하는 시스템이다. 이러한 시스템은 X선 영역에서 공전 주기에 따른 변광을 보이는 특징을 갖고 있는데, 이를 설명하기 위해 intrabinary shock(IBS) 모델을 이용한다. IBS는 두 천체의 항성풍이 상호작용하여 만들어내는 shock인데, 이 shock에서 가속된 입자들이 싱크로트론 기작을 통하여 X선 복사를 한다고 알려져 있다. 복사의 강도는 shock의 기하구조 변화 때문에 밀집성의 공전 위상에 따라서 주기적으로 변하는데, 이를 모형화하여 관측 데이터와 비교함으로써 궤도와 shock의 특성을 알아낼 수 있다. 이 발표에서는 IBS 모델을 설명하고, 이 모델을 매우 복잡한 X선 광도곡선을 보이는 gamma-ray binaries 중 하나인 HESS J0632+057에 적용한다. 그 결과로 이 천체계의 궤도를 추정하고, 동반성 disk와 shock의 상호작용 특성을 파악해보았다.

천문우주관측기술

[구 AT-01] Development of Gravitational Wave Detection Technology at KASI (한국천문연구원의 중력파 검출기술 개발)

Sungho Lee (이성호)[1], Chang-Hee Kim (김창희)[1], June Gyu Park (박준규)[1], Yunjong Kim (김윤종)[1], Ueejeong Jeong (정의정)[1], Soonkyu Je (제순규)[1], Hyeon Cheol Seong (성현철)[1], Jeong-Yeol Han (한정열)[1], Young-Sik Ra (라영식)[2], Geunhee Gwak (곽근희)[2], Youngdo Yoon (윤영도)[2]
[1]Korea Astronomy and Space Science Institute (한국천문연구원), [2]Korea Advanced Institute of Science and Technology (한국과학기술원)

For the first time in Korea, we are developing technology for gravitational wave (GW) detectors as a major R&D program. Our main research target is quantum noise reduction technology which can enhance the sensitivity of a GW detector beyond its limit by classical physics. Technology of generating squeezed vacuum state of light (SQZ) can suppress quantum noise (shot noise at higher frequencies and radiation pressure noise at lower frequencies) of laser interferometer type GW detectors. Squeezing technology has recently started being used for GW detectors and becoming necessary and key components. Our ultimate goal is to participate and make contribution to international collaborations for upgrade of existing GW detectors and construction of next generation GW detectors. This presentation will summarize our results in 2020 and plan for the upcoming years. Technical details will be presented in other family talks.

[구 AT-02] Status of squeezed vacuum experiment and introduction to EPR (한국천문연구원의 진공양자조임 광원 개발 및 EPR 실험 소개)

Chang-Hee Kim (김창희), Sungho Lee (이성호), June Gyu Park (박준규), Yunjong Kim (김윤종), Ueejeong Jeong (정의정), Soonkyu Je (제순규), Hyeon Cheol Seong (성현철), Jeong-Yeol Han (한정열)
Korea Astronomy and Space Science Institute (한국천문연구원),

One of the main limitations to the ground- based gravitational-wave (GW) detector sensitivity is quantum noise, which is induced by vacuum fluctuations entering the detector output port. The replacement of this ordinary vacuum field with a squeezed vacuum field has proven to be effective approach to mitigate the quantum noise in the interferometer detector and it is currently used in advanced detectors. However, the current frequency-independent squeezed vacuum cannot reduce quantum radiation pressure noise at low frequencies. A possible solution to reduce quantum noise in the broadband spectrum is the injection of frequency-dependent squeezed (FDS) vacuum. We will report the current status of squeezing experiment at KASI and introduce to the EPR (Einstein-Podolsky-Rosen) entangled state of light, which can realize FDS light without the need for an additional, external cavity.

[구 AT-03] Frequency dependent squeezing for gravitational wave detectors using filter cavity and international collaboration of a filter cavity project for KAGRA (중력파 검출기의 양자 잡음 저감을 위한 필터 공동기 기반 주파수 의존 양자조임 기술과 KAGRA의 필터 공동기 제작을 위한 국제협력연구)

June Gyu Park (박준규), Sungho Lee (이성호), Chang-Hee Kim (김창희), Yunjong Kim (김윤종), Ueejeong Jeong (정의정), Soonkyu Je (제순규), Hyeon Cheol Seong (성현철), Jeong-Yeol Han (한정열)
Korea Astronomy and Space Science Institute (한국천문연구원),

Radiation pressure noise of photon and photon shot noise are quantum noise limitation in interferometric gravita-tional wave detectors. Since relationship between the two noises is position and momentum of the Heisenberg uncertainty principle, quantum non-demolition (QND) technique is required to reduce the two noises at the same time. Frequency dependent squeezing using a filter