고에너지천문학/이론천문학

[구 HT-01] Estimating Mass and Radius of a Neutron Star in Low-Mass X-ray Binary

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Mass and radius of a neutron star in low-mass X-ray binary (LMXB) can be estimated simultaneously when the observed light curve and spectrum show the photospheric radius expansion feature. This method has been applied to 4U 1746-37 and the mass and radius were found to be unusually small in comparison with typical neutron stars. We re-estimate the mass and radius of this target by considering that the observed light curve and spectrum can be affected by other X-ray sources because this LMXB belongs to a very crowded globular cluster NGC 6441. The new estimation increases the mass and radius but they do not reach the typical values yet.

[구 HT-02] Dependence of tidal disruption flares on stellar density profile and orbital properties

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Tidal disruption events (TDEs) provide evidence for quiescent supermassive black holes (SMBHs) in the centers of inactive galaxies. TDEs occur when a star on a parabolic orbit approaches close enough to a SMBH to be disrupted by the tidal force of the SMBH. The subsequent super-Eddington accretion of stellar debris falling back to the SMBH produces a characteristic flare lasting several months. It is theoretically expected that the bolometric light curve decays with time as proportional to $t^{-5/3}$.

However, some of the observed X-ray light curves deviate from the $t^{-5/3}$ decay rate, while some of them are overall in good agreement with the $t^{-5/3}$ law. Therefore, it is required to construct the theoretical model for explaining these light curve variations consistently. In this paper, we revisit the mass fallback rates semi-analytically by taking account of the stellar internal structure, orbital eccentricity and penetration factor. We find that the mass fallback rate is shallower than the standard $t^{-5/3}$ decay rate independently of the polytropic index, and the orbital eccentricity only changes the magnitude of the mass fallback rate. Furthermore, the penetration factor significantly can modify the magnitude and variation of mass fallback rate. We confirm these results by performing the computational hydrodynamic simulations. We also discuss the relevance of our model by comparing these results with the observed light curves

[구 HT-03] FAR-INFRARED SPECTRAL ENERGY DISTRIBUTION OF THE PULSAR WIND NEBULA 3C 58

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We present analysis results of far infrared (IR) data for 3C 58. We use Herschel observations to measure the IR spectral slope of the source. Our measurements add new IR data points to exisiting high-frequency ones and allow us to improve the IR spectral energy distribution (SED) of 3C 58, and so a cooling break expected in the optical band can be located more precisely. We interpret the SED and the break using a synchrotron+ inverse-Compton model for PWNe and infer flow properties in 3C 58. Because the IR data are contaminated by foregrounds and backgrounds, we discuss impacts of the contamination on our conclusion.

[석 HT-04] Why Are Cool Structures in the Universe Usually Filamentary?

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Small-scale shear flows are ubiquitous in the universe, and astrophysical plasmas are often magnetized. We study the thermal condensation instability in magnetized plasmas with shear flows in relation to filamentary structure formation in cool structures in the universe, representatively solar prominences and supernova remnants. A linear stability analysis is extensively performed in the framework of magnetohydrodynamics (MHD) with radiative cooling, plasma heating and anisotropic thermal conduction to find the eigenfrequencies and eigenfunctions for the unstable modes. For a shear velocity less than the Alfven velocity of the background plasma, the

eigenvalue with the maximum growth rate is found to correspond to a thermal condensation mode, for which the density and temperature variations are anti-phased (of opposite signs). Only when the shear velocity in the k-direction is near zero, the eigenfunctions for the condensation mode are of smooth sinusoidal forms. Otherwise each eigenfunction for density and temperature is singular and of a discrete form like delta functions. Our results indicate that any non-uniform velocity field with a magnitude larger than a millionth of the Alfven velocity can generate discrete eigenfunctions of the condensation mode. We therefore suggest that condensation at discrete layers or threads should be quite a natural and universal process whenever a thermal instability arises in magnetized plasmas.

[구 HT-05] Electron Pre-acceleration in Weak Quasi-perpendicular Shocks in Clusters of Galaxies

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Giant radio relics in the outskirts of galaxy clusters have been observed and they are interpreted as synchrotron emission from relativistic electrons accelerated via diffusive shock acceleration (DSA) in weak shocks of Ms < 3.0. In the DSA theory, the particle momentum should be greater than a few times the momentum of thermal protons to cross the shock transition and participate in the Fermi acceleration process. In the equilibrium, the momentum of thermal electrons is much smaller than the momentum of thermal protons, so electrons need to be pre-accelerated before they can go through DSA. To investigate such electron injection process, we study the electron pre-acceleration in weak quasi-perpendicular shocks (Ms = 2.0 - 3.0) in an ICM plasma (kT = 8.6 keV, beta = 100) through 2D particle-in-cell simulations. It is known that in quasi-perpendicular shocks, a substantial fraction of electrons could be reflected upstream, gain energy via shock drift acceleration (SDA), and generate oblique waves via the electron firehose instability (EFI), leading the energization of electrons through wave-particle interactions. We find that such kinetic processes are effective only in supercritical shocks above a critical Mach number, Ms* ~ 2.3. In addition, even in shocks with Ms > 2.3, energized electrons may not reach high energies to be injected to DSA, because the oblique EFI alone fails to generate long-wavelength waves. Our results should have implications for the origin and nature of radio relics.

[구 HT-06] Radio relics in merging clusters of galaxies

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Clusters of galaxies shape up through a series of hierarchical mergers. It is believed that major mergers lead to cluster-wide shock waves, which are manifested as radio relics. The 1RXS J0603.0+4213 and CIZA J2242.8+5301 clusters, for instance, contain Mpc-size giant radio relics in the outskirts. Synchrotron emission from these radio relics reveals the presence of relativistic electrons and the magnetic fields of a few μG strength. The presence of such magnetic fields in the ICM has been explained by the so-called small-scale turbulent dynamo. To get quantitative measures for magnetic fields in clusters of galaxies, we investigate the development of turbulence and the follow-up amplification of magnetic fields through three-dimensional numerical magnetohydrodynamical (MHD) simulations. The turbulence is induced in highly stratified cluster media, and driven sporadically by major mergers. We here present the results, aiming to answer whether the turbulence dynamo scenario can explain the observed strength and scale of magnetic fields in clusters. Also, we discuss whether the observed properties of giant radio relics can be reproduced in our simulations.

태양/태양계

[구 SS-01] The wave nature of halo coronal mass ejections (파동으로서의 태양 코로나질량방출 현상 연구)

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햇무리(halo) 모양 코로나질량방출(coroanl mass ejection) 현상은 1970년대 후반 처음 발견된 이후, 그 물리적 본질에 대해 많은 논쟁이 있었다. 우주 망원경 SOHO LASCO의 고분해능 관측이후, 햇무리 모양은 시선 방향에 나란한 방향으로 팽창하며 진행하는 고깔모양의 자기 구조(cone-shaped magnetic flux rope)가 2차원 관측이미지에 투영된 것으로 해석하는 것이 정설이다. 우