We describe relations between modern cosmology and general relativity in the historical context. We reveal some ironies imbedded in Einstein's final correction of his gravitational field equation in the context of cosmology in 1917 which has apparently opened a new era of modern physical cosmology. The ugly (according to Einstein) correction term was introduced only to build a static cosmology which turns out to be in flat contradiction with observation. Somehow, however, it is the correction term which has saved the modern cosmology from the genuine creativity of nature continuously revealed by astronomical observations. Whether the present precision cosmology is also a correct one is often ignored by the practitioners but still a pressing open question left for future theoretical and observational pursuits.

[구 GR-03] Gravitational-wave detection - for the new age of astronomy (중력파 검출 - 새로운 천문학의 시대를 위하여)

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Gravitational-wave has been predicted by Einstein's general relativity in 1916, but its direct detection has failed to date despite of the persistent efforts in the last fifty years in the ground-based gravitational wave detectors. In the centennial year of the birth of general relativity, 'advanced LIGO', one of the most promising Earth-based gravitational wave detectors, plans to start commissioning for the successful discovery of gravitational waves. In addition, a pathfinder satellite of eLISA project, a space-based GW antenna by European Space Agency (ESA), will be launched in the mid of this year. In this talk, we review the current status of gravitational waves detection experiments and discuss its scientific impacts and the possibility of opening the new age of astronomy.

성간물질 / 우리은하

[구 IM-01] MHD Turbulence in Expanding and Contracting Media

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We investigate the decaying incompressible MHD turbulence by including the effect of the expansion and contraction of background medium. In such an environment, incompressible MHD turbulence has two kinds of time scale. One is the eddy turn-over time (teddy), the other is the expansion/contraction time (texp-cntr). The turbulence is expected to behave differently according to the relationship between the two time scales. For instance, for teddy < texp-cntr, the turbulence would be decay more or less as in a static medium. On the other hand, for teddy > texp-cntr, the effects of expansion and contraction would be dominant. We examine the properties of turbulence in these two regime cases. Based on it, we derive a scaling for the time evolution of flow velocity and magnetic field. (i) In the decay effect dominant case, the velocity and magnetic field scale as $\sqrt{\rho}\,\mathrm{v} \sim \mathrm{a}^{-3}$, $\mathrm{b} \sim \mathrm{a}^{-2.5}$ (expanding media) and $\sqrt{\rho}\,\mathrm{v} \sim \mathrm{a}^{-2}$, $\mathrm{b} \sim \mathrm{a}^{-1.5}$ (contracting media). The total energy and residual spectra follow the $E_k^{\mathrm{T}} \sim k^{-5/3}$, $E_k^{\mathrm{R}} \sim k^{-7/3}$ in the inertial range. (ii) In the expanding and contracting dominant case, the velocity and magnetic field scale as $\sqrt{\rho}\,\mathrm{v} \sim \mathrm{a}^{-2.5}$, $\mathrm{b} \sim \mathrm{a}^{-2}$ (expanding/contracting media). The Kinetic and magnetic energy spectra follow the $E_k^{\mathrm{K}} \sim a^{-5}$, $E_k^{\mathrm{M}} \sim a^{-4}$. We have confirmed that scaling of velocity and magnetic filed is almost the same from the analytic estimates and computational models.

[구 IM-02] Expansion of Dusty H II Regions and Its Impact on Disruption of Molecular Clouds

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Dynamical expansion of H II regions plays a key role in dispersing surrounding gas and therefore in limiting the efficiency of star formation in molecular clouds. We use analytic methods and numerical simulations to explore expansions of spherical dusty H II regions, taking into account the effects of direct radiation pressure, gas pressure, and total gravity of the gas and stars. Simulations show that the structure of the ionized zone closely follows Draine (2011)'s static equilibrium model in which radiation pressure acting on gas and dust grains balances the gas pressure gradient. Strong radiation pressure creates a central cavity and a compressed shell at the ionized boundary. We analytically solve for the temporal evolution of a thin shell, finding a good agreement with the numerical experiments. We estimate the minimum star formation efficiency required for a cloud of given mass and size to be destroyed by an HII region expansion. We find that typical giant molecular clouds in the Milky Way can be destroyed by the gas-pressure driven expansion of an H II region, requiring an efficiency of less than a few percent. On the other hand, more dense cluster-forming clouds in starburst environments can be destroyed by the radiation pressure driven expansion, with an efficiency of more than ~30 percent that increases with the mean surface density, independent of the total (gas+stars) mass. The time scale of the expansion is always smaller than the dynamical time scale of the cloud, suggesting that H II regions are likely to be a dominant feedback process in protoclusters before supernova explosions occurs.

[구 IM-03] Efficient simulation method for a gas inflow to the central molecular zone

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We present hydrodynamic simulations of gas clouds that inflowing from the disk to a few hundred parsec region of the Milky Way. Realistic Galactic structures are included in our simulations by thousands of multipole expansions that describe 6.4 million stellar particles of a self-consistent Galaxy simulation (Baba, Saitoh & Wada, in prep.). We find that a hybrid multipole expansion model with two different basis sets and a thick disk correction well reproduces the overall structures of the Milky Way. We find that the nuclear ring evolves into 240 pc at T~1500 Myr, regardless of the initial size. For most of simulation runs, gas inflow rate to the nuclear region is equilibrated as ~0.02 Msun/yr, and thus accumulated gas mass and star formation activity is stabilized as 6 x10^7Msun and ~0.02M/yr, respectively. These stabilized values are in a good agreement with estimations for the CMZ. The nuclear ring is off-centered to the Galactic center by the lopsided central mass distribution of the Galaxy model, and thus an asymmetric mass distribution is arose accordingly. The lopsidedness also leads the nuclear ring to be tilted to the Galactic plane and to precess along the Galaxy rotation. In early evolutionary stage when gas clouds start to inflow and form the nuclear ring, the z-directional oscillations of the gas clouds results in the twisted, infinity-shaped nuclear ring. Since the infinity-shaped feature is transient only for first 100 Myr, the current infinity-shape observed in the CMZ may indicate that the CMZ forms quite recently.

[구 IM-04] Simultaneous observations of the H2O and SiO masers toward the late-type stars using KVN

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We present the results of simultaneous observations of the H2O and SiO masers emitted from the circumstellar envelopes of the late-type stars. These observations have been carried out at the K and Q bands using KVN since 2014 August and were scheduled to test the feasibility of multi-frequency phase referencing analysis on the maser lines. In order to increase the accuracy of group delay solution in the fringe search on the continuum source, the IF channels were randomly distributed within the available bandwidth of 500 MHz in each band. The positions of all maser spots are relatively described with respect to the position of the reference continuum source through the source frequency phase referencing technique, and this provides the astrometric position accuracy. Therefore, the relative locations of the H2O maser spots with respect to the SiO maser spots are determined from our observations, and the capability of the simultaneous multi-band observation of KVN is proved to be powerful to study the maser pumping mechanism around the late-type stars.

[구 IM-05] Clustering properties and halo occupation of Lyman-break galaxies at z ~ 4

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