N-body Simulations of the Small Magellanic Cloud and the Magellanic Stream

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An extensive set of N-body simulations has been carried out the gravitational interaction of the Small Magellanic Cloud (SMC) with the Galaxy and the Large Magellanic Cloud (LMC). The SMC is assumed to have been a barred galaxy with a disc to halo mass ratio of unity before interaction and was modelled by a large number of self-gravitating particles, whereas the Galaxy and LMC have been represented by rigid spherical potentials. We have employed orbital parameters for the Magellanic Clouds derived by Gardiner et al. (1994) (MNRAS 266, 567). The best simulation we have found succeeded in matching a number of observational characteristics of the Magellanic system. The Magellanic Stream (MS) was reproduced as a tidal plume created by the perigalactic passage of the SMC 1.5 Gyr ago in similar way to the model of Murai & Fujimoto (1980) (PASJ 32,581) but with significant improvements in morphology and velocity structure. A novel feature of the model is the formation of a leading arm on the opposite side of the Magellanic Clouds to the Magellanic Stream. which we propose is identified with several neutral hydrogen clumps observed in the corresponding region of the sky. The elongation of the SMC bar along the line-of-sight direction suggested by Cepheid observations has been partially reproduced, alongside its projected appearance on the sky. We also showed that the underlying velocity structure of the H I gas in the central regions is due to the regular kinematics of the bar. Certain velocity-distance correlations for the stellar populations of the SMC have been explained as a result of the LMC's tidal perturbation. Lastly, the model successfully describes major trends in the overall velocity pattern for the gas, young stars, and carbon stars in the inter-Cloud region.

Photometric Evolution of Elliptical Galaxies

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We have calculated the photometric evolution of elliptical galaxies taking into account the time variation of metallicity during chemical evolution and the stellar evolutionary models covering the wide ranges of metallicity and mass, and adopting the different IMFs (simple IMF & time-dependent bi-modal IMF).

The model with a simple IMF can't reproduce the observed integrated properties(magnitudes and colors). However, by using the time-dependent bi-modal IMF, we could obtain reasonable models which can reproduce the observed integrated properties. These models show the following properties of giant elliptical galaxies. (1) Most of stars are born within 2Gyr and the metallicity increases abruptly up to [Fe/H] $\sim$ 0.6 during the very early phase(1Gyr) of the evolution. (2) The integrated color and magnitude become redder

and fainter slowly during the later phase. (3) A synthetic galaxy appears the maximum brightness at ~ 1Gyr which is about 2,500 times of the present brightness(t=15Gyr). (4) The star formation is still continued, although the number of stars which were born during the period of recent 1Gyr is very small (~1% of total number of stars). (5) A significant effect of metallicity spread is shown in the main sequence on C-M diagram. (6) The contribution of giants to the total luminosity is about 32 ~ 58% and average metallicity is about 2.9 ~ 4.0Z⊙.

Effects of 10 M⊙ Black Holes on the Dynamical Evolution of Galactic Nuclei

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A star with main sequence mass greater than 25 ~ 30M⊙ may collapse to a black hole of about 10 M⊙ at the final stage of the evolution. About an order of 1% of stellar mass is likely to be in form of such black holes in galaxies. We have examined the dynamics of two-component stellar systems composed of 0.7 M⊙ main-sequence stars, representing the old population of stars whose main-sequence lifetimes are longer than the Hubble time, and a small fraction of 10 M⊙ black holes. The dynamical friction leads to the segregation of black holes to the core and the core collapse takes place among the black holes in a time scale much shorter than that required for a single component cluster. The ultimate evolution of the two-component stellar system depends on the role of three-body binaries formed among the black holes. For a system with $\upsilon \gtrsim$ 100km/sec binaries merge by gravitational radiation at some hardness instead of being ejected. the critical hardness, at which the collision time and the merger time become comparable, determines the efficiency of the binary as a heat source. The efficiency is found to be inversely proportional to the velocity dispersion. For the clusters without serious reduction in heating efficiency (i.e., velocity dispersion well below 500 km/sec), heating by three-body binaries have the effect of stopping the core-collapse. The cluster expands, but at a rate set by the half-mass relaxation time of the whole system which is very long. Thus one obtains nearly static two-component configuration: central cluster of black holes surrounded by low mass clusters. However, such a state would not last longer than Hubble time if $\upsilon \gtrsim$ 50km/sec because most of the black holes would experience binary formation and subsequent mergers. A seed black hole can easily form in the central parts of galaxies with even moderate initial conditions (i.e., $\upsilon c \gtrsim$ 100km/sec).

VARIABILITY OF ACTIVE GALACTIC NUCLEI DUE TO FIELD-ACCRETING MODES

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Variability of the emission-line spectra of active galactic nuclei is now a well-known phenomenon. This remains to be fully explained by a theoretical model of the central engine