evolution of perturbed gaseous disks has been studied by Sorensen (33.151.030). Biermann (29.151.072) has presented a new code to calculate the evolution of galaxies.

Recently, the interaction of stars with fluctuations of the galactic gravitational field due to massive objects or short-lived spiral perturbations, as reviewed by Wielen and Fuchs (1984), has found special interest. The resulting secular evolution of galaxies has been studied by Carlberg (37.151.006), Carlberg and Sellwood (33.151.029), Carlberg, Freedman and Sellwood (34.151.052), Icke (31.151.018), Kamahori and Fujimoto (37.151.061), Lacey and Fall (34.155.006, 1984), Lacey (37.151.007, 37.151.076), Rohlfs and Wiemer (32.151.008), Villumsen (34.151.089, 37.151.102, 1984), Wielen and Fuchs (32.151.072, 32.151.073, 33.151.070, 34.151.104).

4. References

Grivnev, E.M., Ivannikova, E.I., Maksumov, M.N.: 1984, Astron. Zh. (in press).
Johns, T.C., Nelson, A.H.: 1985, IAU Symposium No. 106.
Lacey, C.G., Fall, S.M.: 1985, IAU Symposium No. 106.
Ogorodnikov, K.F., Osipkov, L.P.: 1980, Byull. Abastumansk. Astrofiz. Obs. 52, 37.
Sellwood, J.A., Carlberg, R.G.: 1984, Astrophys. J. (in press).
Sparke, L.S.: 1984, Astrophys. J. (in press)
Ueda, R., Noguchi, M., Iye, M., Aoki, S.: 1984, ESO Sci. Prepr. No. 310.
Villumsen, J.V.: 1985, IAU Symposium No. 106.
Wielen, R., Fuchs, B.: 1985, IAU Symposium No. 106.

E. COMPUTER SIMULATIONS

Computer simulations provide a powerful tool for investigating the evolution of gravitating systems.

1. Clustering of Galaxies

Using the Monte-Carlo simulation technique, Dodd et al. (31.151.028) and MacGillivray and Dodd (31.160.074, 31.160.075, 32.160.055, 32.160.056) investigated the geometric properties of positions, orientations, shapes, etc. of galaxies in clusters.

Ishizawa et al. (32.151.022), Carnevali et al. (30.151.048), and Guiricin et al. (37.160.078) examined the dynamical evolution of a group of galaxies. Miller (34.151.018) showed that the observed structure of galaxy clusters and superclusters is most easily described in terms of matter being swept away from growing empty regions in an expanding universe. A two-dimensional simulation of the gravitational superclustering of collisionless particles was carried out by Melott (33.161.016). Bhavsar et al. (29.151.085) supported the gravitational instability picture for clustering, in which the multiplicity function depends strongly on the initial density fluctuation spectrum index.

Saslaw and Aarseth (31.162.015) examined the evolution of the velocity distribution of galaxies as they cluster in the expanding universe and showed that the velocity dispersion of extreme field galaxies is a good cosmological indicator of Ω. To estimate Ω, Miller (1984) made also numerical experiments on galaxy clustering in open universes. Shaya (37.160.113) made Monte-Carlo simulations to determine the probability distribution of peculiar velocities and shear velocities of superclusters.

The merging rate of galaxies in an expanding universe for explaining the galaxy mass function was derived by Roos (29.151.035). The evolution of rich clusters of galaxies with halo was simulated by Roos and Aarseth (32.160.042). Farouki et al. (34.151.020) examined the collapse and violent relaxation of N-body systems, and found the mass segregation and the secondary density maximum similar to those observed in some cD clusters of galaxies. Malumuth and Richstone (37.160.024) simulated the evolution of galaxy clusters with different richness, and confirmed that the central region of the cD clusters is produced by mergers while the halo is produced by stripping. N-body simulations of galaxy clustering was compared with observations by Zieba et al. (31.151.007).

2. Interacting Galaxies

Simulations of galaxy mergers were reviewed by White (33.151.059). A new technique for simulating galactic collisions was proposed by James (30.151.061).

Villumsen (31.151.041, 34.151.008) carried out N-body simulations of mergers of two spherical non-rotating systems with isothermal or Hubble density profile, and showed that the density profiles of the remnants are inconsistent with the de Vaucouleurs law. Farouki and Shapiro (29.151.018) simulated the passage of a flat disk galaxy through the core of a cD cluster, and suggested that only the flattest of E-galaxies could be created from the disk systems through repeated collisional heating.

The collision and merging of two disk-halo galaxies were investigated by Gerhard (30.151.018), Smith and Miller (33.151.063), and Negroponte and White (34.151.057). The collision of two spherical isothermal systems with a central core was studied by Carlberg (31.151.082). Farouki and Shapiro (32.151.004) found a criterion for the merging of two identical disk-halo galaxies.

Quinn (37.151.079) showed that the interaction between disk and elliptical galaxies creates shell-like features in the outer regions of E-galaxies. The tidal interaction between galaxies was simulated by Chatterjee Ahmed (29.151.022), and Korovyakovskaya and Korovyakovskij (33.151.010). Duncan et al. (34.151.021) applied N-body simulations to galactic cannibalism. The decay of satellite galactic orbits was simulated by Lin and Tremaine (33.151.004) and White (34.151.077).

3. Gravitational Collapse of Protogalaxies

Based on a numerical integration of the collisionless Boltzmann equation, Fujiwara (34.151.063) studied the evolution of the distribution function during the collapse of a homogeneous sphere. Fujiwara (33.161.125, 1983) examined also the collapse of massive neutrinos which yields a core-halo structure. Collapses of stellar protogalaxies which lead to the elliptical or bar deformation were investigated by Polyachenko (29.151.012), and Miller and Smith (29.151.029). Collapses of pressureless inhomogeneous spheroids were examined by Goodman and Binney (33.151.012), and Noguchi (1984).

The formation of galactic halos during the secondary infall was simulated by Dekel et al. (30.151.055), and Pryor and Lecar (33.151.133). Van Albada (32.151.065), and May and van Albada (1984) showed that a variety of irregular initial conditions produce density distributions in agreement with the $r^{1/4}$ law. The formation of E-galaxies was also simulated by Doroshkevich and Klypin (29.151.046), and McGlynn (37.151.095). Among remnants of merging simulations, Gerhard (33.151.013, 33.151.018) found out quasi-stable principal axis twists in models of elliptical galaxies.

In numerical experiments on the protogalactic collapse, Miller and Smith (29.151.036) investigated the effect of star formation, and Carlberg and Hartwick (30.151.036) considered an instantaneous mass loss.

4. Evolution of Galactic Structures

Taking into account of the scattering of stars out of the plane due to giant molecular clouds, Villumsen (34.151.089) simulated the evolution of the vertical structure of galactic disks. Integrating numerically the Boltzmann and Poisson equations, Watanabe et al. (30.151.083), Nishida et al. (30.151.084), and Nishida (33.151.096) investigated the evolution of the flat stellar disks. Inagaki et al. (1984) investigated the reliability of two totally independent numerical methods in simulating the evolution of disk galaxies. Numerical experiments on the evolution of a rotating stellar bar were made by Miller et al. (32.151.018), and Carnevali (33.151.011). Self-gravitating warps in disk galaxies were examined by May and James (37.151.010). Thielheim and Wolf (37.151.015) simulated the development of bar and spiral structure in a self-consistent way.

The evolution of the spiral structure in flat galaxies was also investigated by computer simulations: The stellar and gas responses to oval distortions in disk galaxies were studied by Thielheim and Wolff (29.151.052), and Sorensen and Matsuda (31.151.008), respectively. Levinson and Roberts (29.151.058) investigated the evolution of the system of clouds in response to a background spiral density wave of a model galactic disk. The process of stochastic self-gravitating star formation was simulated by Comins (29.151.001), Seiden and Gerola (31.151.084), and Statler et al. (34.151.002).

5. Evolution of Star Clusters

Based on extensive orbital calculations of elliptic and circular three-body systems, Keenan (29.151.033, 29.151.034) investigated the galactic tidal limits and outer structure of star clusters. Monte-Carlo simulations of the evolution of galactic nuclei and star clusters with a central black hole were carried out by Duncan and Shapiro (31.151.016, 33.158.163).

Binaries in star clusters are important for the energy budget, absorbing energy from and injecting energy into the clusters. Hut and Bahcall (33.151.118) and Hut (34.151.037) carried out numerical orbit calculations for binary-single star scattering, and showed that soft binaries become softer while hard binaries become harder through the heat exchange process. Fullerton and Hills (31.151.021), and Hills (34.151.003) simulated also encounters between binary and single stars.

Encounters between pairs of binary to obtain various cross-sections were simulated by Mikkola (32.151.077, 33.151.102, 34.151.041) and Hoffer (34.151.014); see also Dokuchaev and Ozernoj (29.151.010, 29.151.013, 31.151.067, 31.151.068, 32.151.003) for the dynamical role of binaries in star clusters.

Based on a N-body simulation, the relaxation processes of one-dimensional self-gravitating system were investigated by Wright et al. (32.151.014), Luwel and Severne (33.151.017), and Severne et al. (1984). Smith (29.151.008) and Farouki and Salpeter (31.151.014) carried out N-body simulations to determine the timescales of relaxation and segregation, respectively.

6. References

Fujiwara, T.: 1983, Theor. Phys. 70, 603.
Inagaki, S., Nishida, M.T., Sellwood, J.A.: 1984, Mon. Not. R. Astr. Soc. (in press)
May, A., van Albada, T.S.: 1984, Mon. Not. R. Astr. Soc. 209, 15.
Miller, R.H.: 1984, Astron. Astrophys. 138, 121.
Severne, G., Luwel, M., Rousseeuw, P.J.: 1984, Astron. Astrophys. 138, 365.

https://doi.org/10.1017/S0251107X00006519 Published online by Cambridge University Press