RevMexAA (Serie de Conferencias), **14**, 91–91 (2002)

FORMATION AND EVOLUTION OF DISK GALAXIES

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Using a self-consistent model of galaxy formation and evolution within the context of the Cold Dark Matter (CDM) scenario, we find the fundamental parameters of disk galaxies.

Galaxies are the ecosystems where stars are born, live and die interacting with the ISM, and on the other hand they are the structural unities of the universe. Therefore, the understanding of galaxies should come from both approaches: the deductive one (from cosmological initial conditions to present day galaxies) and the inductive one (tracing the past of galaxies from the fossil- present-day properties). One of the crucial questions about galaxies is which cosmological initial conditions and/or astrophysical processes are relevant in giving rise to their properties, correlations and evolutionary features, in particular to the Hubble sequence (HS). The model we developed takes into account both approaches and is aimed to explore these questions.

Star formation (SF) is a key process in galaxy evolution. Firmani & Tutukov (A&A,264,37,1992) introduced a model of disk large-scale SF, where SF is triggered by gravitational instabilities and self-regulated by a balance between the SN energy input and the energy dissipated due to turbulent motions in the ISM. The model predicts the observed dependence of $\dot{\Sigma}_{\rm SFR}$ on $\Sigma_{\rm gas}$ and shows that normal galaxies would consume their gas in $t \lesssim 3-5$ Gyr. Then, gas infall is necessary, in agreement with results of inductive approaches as the chemical evolution models. In the context of the CDM picture, galaxies form through a continuous process of mass aggregation. Assuming that smooth accretion dominates over mergers, we model the formation of disks in centrifugal equilibrium within growing CDM halos (Avila-Reese et al. 1998; Firmani & Avila-Reese 2000). Thus, the SF history of the galaxy models is driven by the gas infall rate (cosmological accretion) and the disk gas surface density determined mainly by the spin parameter λ of the halo. Bulge forms from secular evolution of the stellar disk.

From our models, we conclude that the main properties of disk galaxies (exponential surface brightness (SB) profiles, nearly flat rotation curves, local and global color indexes, gas fractions f_g, etc.) as well as their correlations (Tully-Fisher (TF) and magnitude-radius relations, the HS, etc.) are the result of the combination of 3 cosmological factors and their dispersions: *mass, mass aggregation history (MAH) and* λ. The last 2 determine the intensive properties and are on the basis of the HS correlations. The MAH influences on the galaxy color, f_g, and halo structure while λ influences on the SB, b/d ratio and rotation curve shape. The higher the SB and the redder the disk, the larger the b/d ratio and the lower the gas fraction. The mass almost does not influence these properties, the HS being probably a bi-parametrical sequence driven by the MAH and λ (Avila-Reese & Firmani 2000). The model HS correlations are less scattered than observations; processes of secondary importance for disk galaxies, as mergers and non-stationary SF, could produce more spread around the predicted correlations.

A potential shortcoming of the CDM scenario is the high concentration it predicts for the halo cores. We have re-simulated our models allowing for the formation of shallow cores in the CDM halos in such a way that they resemble the cores of LSB and dwarf galaxy halos. The shapes of rotation curves, the maximum disk-to-total circular velocity ratios, and the zero-point of the TF relation reach better agreement with the observational information. However, the structure, SF, luminosity and colors, f_g, b/d ratios, etc. are affected minimally by the core softening of the CDM halos, remaining the same our predictions. Definitively, the CDM scenario offers a powerful theoretical background to understand the origin and properties of galaxies.

This work was supported in part by CONACyT grant 33776-E to V.A.

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