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*Dissertation Summary*

# Structure and Dynamics of Early-Type Disk Galaxies

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This study addresses different issues arising from the analysis of the interplay between the ionized gas and stellar kinematics observed in a sample of 16 early-type disk galaxies. The presence and the amount of dark matter in Sa spiral galaxies, the dynamical state of the ionized gas in S0 galaxies, and the detection of kinematical decoupling between different components of S0 and Sa galaxies provide useful clues to processes which led to the formation and later contributed to the evolution of lenticular and early-type spiral galaxies. The morphology and structure of the selected galaxies have been investigated by combining the kinematical and photometric data obtained by means of long-slit spectroscopy at intermediate resolution and by broadband and narrowband imaging, respectively.

1. The stellar and ionized gas velocity curves and velocity dispersion profiles have been measured along the major axis of six early-type spiral galaxies. Two of these galaxies, namely NGC 2179 and NGC 2775, were particularly well suited to be studied with a Jeans modeling technique, which adopts the potential directly derived from the surface brightness distribution of the stars. Both stellar and gaseous kinematics have been modeled to derive the mass contribution of luminous and dark matter to the total potential. For these very luminous Sa galaxies, it turns out that there is an extended region (inside the optical radius $R_{\rm opt}$) where mass is essentially traced by light. In particular, in NGC 2775 the halo contribution is negligible inside $0.6R_{\rm opt}$, whereas in the less luminous NGC 2179 the contributions of dark and visible matter to the total mass are comparable at $R_{\rm opt}$ (E. M. Corsini et al., 1999, A&A, 342, 671).

2. Studying the major-axis kinematics for both the stellar and gaseous components of a sample of eight S0 galaxies, we found that the central velocity dispersion of the ionized gas usually exceeds 150 km $s^{-1}$. This value is far higher than the one expected from thermal motions or small-scale turbulence ($\sim$50 km $s^{-1}$). Since in some galaxies the gas velocity dispersion remains as high as the stellar one over an extended radial range, it is suggested that random motions could be crucial for the dynamical support of the gas (F. Bertola et al., 1995, ApJ, 448, L13). Such a pressure support may explain why the observed gas rotation curves in galaxy bulges often fall short of the circular velocity predicted from the stellar kinematic models. This is the case of the S0 galaxy NGC 4036. We explored different avenues to understand the dynamical state of the ionized gas in the bulge region of this galaxy (P. Cinzano et al., 1999, MNRAS, 307, 433). In fact, we assumed the gaseous component to be a collisionless ensemble of cloudlets either in hydrostatic equilibrium or resulting from the recent mass loss of the bulge stars. Moreover, we considered the effects on the kinematics of the gas cloudlets due to the drag force produced by the interaction with the hot component of the interstellar medium. All these approaches provide a much better description of the data than cold gas on closed orbits, but a definitive model to describe the observed gas kinematics at all radii is not yet available.

3. The projection effects due to galaxy orientation have to be taken into proper account in studying the dynamical nature of the multiple components of ionized gas, which are sometimes observed in disk galaxies. This is the case of the two kinematically distinct gaseous components detected in the Sa galaxy UGC 10205 and giving rise to the velocity curve with a "figure-of-eight" appearance (J. C. Vega Beltrán et al., 1997, A&A, 324, 485). They have been respectively interpreted as gas onto closed nonintersecting orbits associated to a bar and in a ring formed at the outer Lindblad resonance. These two gaseous components are viewed superimposed along the line of sight due to the high inclination of UGC 10205.

4. An intriguing example of the presence of kinematically decoupled components in spiral galaxies is represented by the case of the Sa galaxy NGC 3593 (F. Bertola et al., 1996, ApJ, 458, L67). The analysis of its stellar kinematics and surface brightness distribution reveals that NGC 3593 hosts two exponential stellar disks of different scale lengths and different central surface brightnesses counterrotating with respect to one other. The ionized gas disk corotates with the smaller and less massive stellar disk and counterrotates with respect to the larger and more massive one. The stellar and gaseous counterrotations detected in NGC 3593 are interpreted as the end result of an acquisition in a retrograde way of a large amount of gas from the environment.

The presence of a circumnuclear ring of ionized gas (E. M. Corsini et al., 1998, A&A, 337, 80) can be considered as the signature of the past interaction between the preexisting prograde gas of the galaxy and the acquired retrograde gas, which first settled onto the equatorial plane of the galaxy, giving rise to the gaseous disk we now observe, and then formed the inner counterrotating stellar disk.

5. The origin and nature of the counterrotation is extensively discussed according to the kind of the counterrotating components (i.e., stars vs. gas, stars vs. stars, and gas vs. gas) and to the morphological type of the host galaxies ranging from ellipticals to S0's and to spirals (F. Bertola & E. M. Corsini, 1999, in IAU Symp. 186, Galaxy Interactions at Low and High Redshift, ed. J. Barnes & D. B. Sanders [Dordrecht: Kluwer], 149). In general, counterrotation is considered a sort of fingerprint, revealing that the host galaxy experienced a second event in its history.

6. The structure of the Sa galaxy NGC 4698 is a clear indication that second events can play a crucial role in reshaping galaxies after their formation. The *R*-band isophotal map of this spiral shows that the inner region of the bulge structure is elongated perpendicular to the major axis of the disk, and this is also true for the outer parts of the bulge if a parametric photometric decomposition is adopted. At the same time, the stellar component is characterized by an inner velocity gradient and a central zero-velocity plateau along the minor and major axes of the disk, respectively. This remarkable geometric and kinematic decoupling suggests that a second event occurred in the formation history of this galaxy. According to this framework, two alternative scenarios are discussed: either the entire disk was accreted around a bare triaxial spheroid previously formed, or the bulge harbors an isolated core (F. Bertola et al., 1999, ApJ, 519, L127).