KINEMATICS OF GAS AND STARS IN SPIRAL GALAXIES

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In order to investigate the interplay between the morphological and kinematical properties of disk galaxies we measured and analyzed the kinematics of ionized gas and stars along the major axis of a sample of 20 unbarred S0 and spiral galaxies. In the outer regions of all the sample galaxies the stellar rotation velocity is comparable to that of the ionized gas ($\Delta V_\star \approx \Delta V_{\rm gas}$), while in the inner regions the following kinematic features are noteworthy.

In central regions of the late-type spirals we observe almost the same velocity gradient for both stars and gas ($\Delta V_\star/\Delta r \approx \Delta V_{\rm gas}/\Delta r$). The same is true for their velocity dispersion ($\sigma_\star \approx \sigma_{\rm gas}$), which are characterized by low values (~ 50 km s^{-1}) over all the observed radial range. As an example of this kind of kinematics we show in Figure 1 the Scd galaxy NGC 1160. This is also the case of NGC 949 (Sc) and NGC 2541 (Scd). We deduce that in most of the late-type spirals we studied the stars and the ionized gas are virtually moving at the circular velocity.

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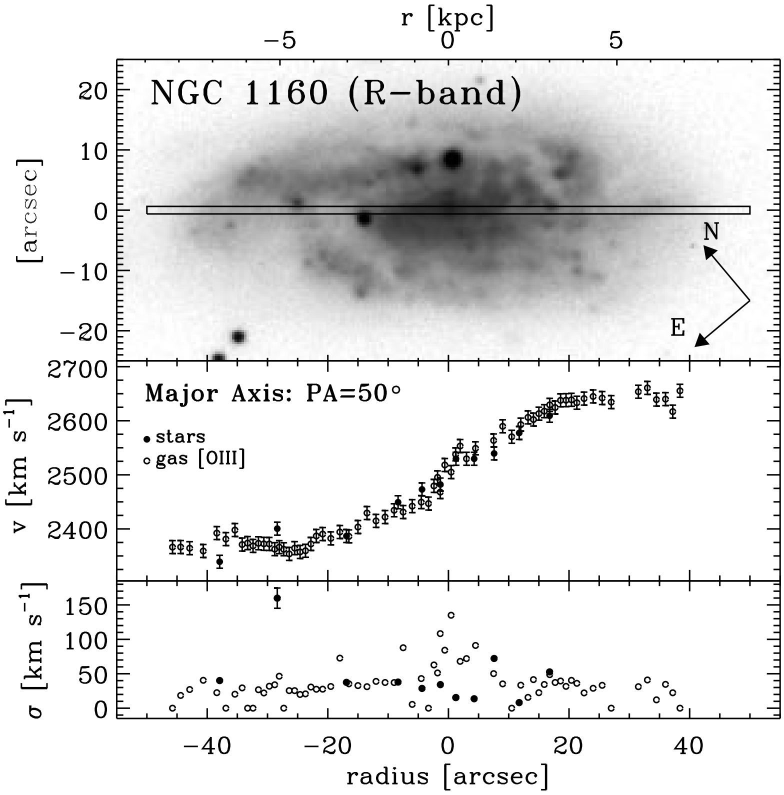

Figure 1. Ionized gas and stellar kinematics along the major axis of the late-type spiral NGC 1160. In the upper panel the position of the slit of the spectrograph is plotted superimposed to an R−band image of the galaxy The velocity curves (middle panel) and the velocity dispersion profiles (lower panel) of the gaseous (open circles) and stellar (filled circles) components are plotted

The central parts of early-type disk galaxies reveal a wider variety of different behaviors of stars and gas. We usually measured for stars and gas $\Delta V_\star/\Delta r < \Delta V_{\rm gas}/\Delta r$ and $\sigma_\star > \sigma_{\rm gas} \sim 50$ km s^{-1} (e.g. NGC 5064, NGC 7782). This can be easily explained by considering that the stellar and gaseous kinematics are dominated by dynamical pressure and rotation respectively. The observed stellar rotation can be corrected into that corresponding to the circular velocity traced by the gas rotation taking into account the asymmetric drift effect (e.g. Binney & Tremaine 1987). In the early-type disk galaxies NGC 772, NGC 980 and NGC 3898, we derived $\Delta V_\star/\Delta r \approx \Delta V_{\rm gas}/\Delta r$ and we found $\sigma_\star \approx \sigma_{\rm gas} \geq 120$ km s^{-1} over an extended radial range. In Figure 2 we show the kinematics of the Sa NGC 3898. The presence of the gaseous component with a high central velocity dispersion has been previously detected in the nucleus of

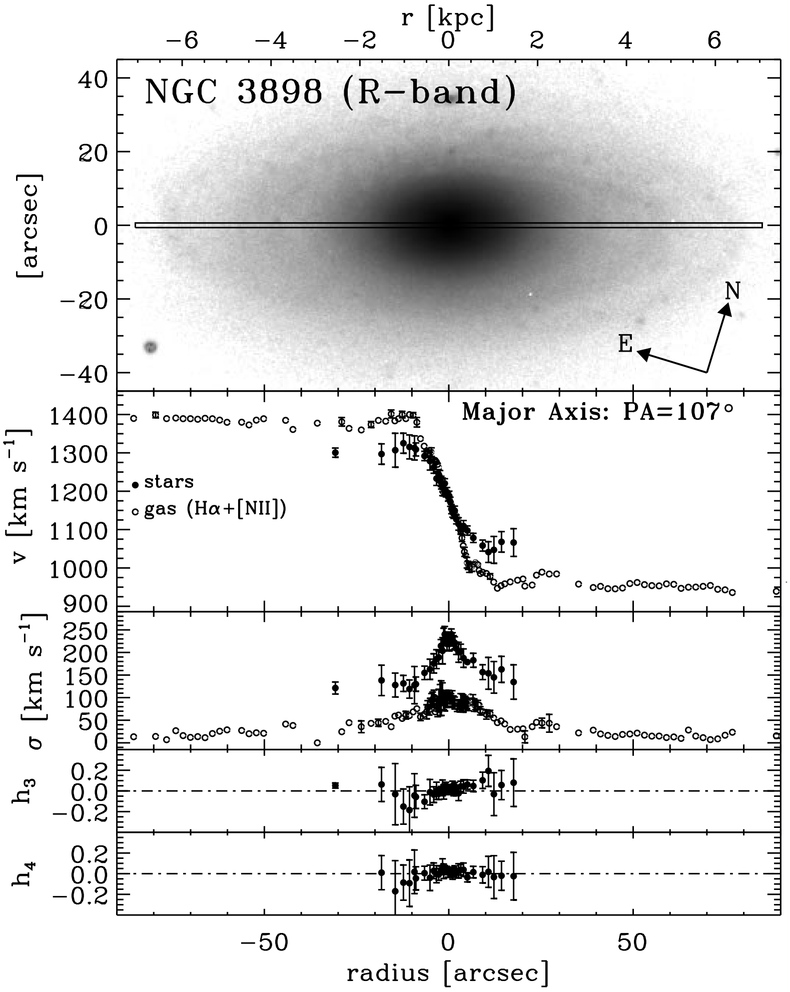

Figure 2. Same a Fig. 1 for the early-type spiral NGC 3898. In the two additional panels the radial profiles of Gauss-Hermite coefficients h_3 and h_4 are plotted

some lenticulars and early-type spirals by different authors (Fillmore et al. 1986, Kent 1988, Kormendy & Westpfahl 1989). It has been explained by Bertola et al. (1995) showing that random motions are also crucial for the dynamical support of the gas (e.g. see the detailed model for NGC 4036 by Cinzano et al. 1998). The peculiar stellar and/or gaseous kinematics of the remaining early-type spiral of the sample is due to the presence of triaxial (e.g. NGC 3521, NGC 4419), counterrotating (e.g. NGC 2841, NGC 7331) or kinematically decoupled (e.g. IC 4889, NGC 4698) components. These components have been detected (even when they were photometrically unresolved) due to the hallmarks they leave in the observed kinematics (e.g. "wavy pattern" rotation curves, "figure-of-eight" rotation curves "M-shaped" velocity dispersion profiles, h_3 peculiar radial profiles).

In order to investigate quantitatively the relationship between the kinematics of stars and gas and the mass distribution of spirals we adopted the self-consistent dynamical models by Pignatelli & Galletta (1998). The models derive from the stellar data the gravitational potential in which the ionized gas is expected to orbit. They take into account the asymmetric drift effects, the projection effects along the line-of-sight and the non-Gaussian shape of the line profiles due to the presence of different components with distinct dynamical behavior.

The number of galaxies belonging to the sample is not large enough to draw general conclusions. Anyway we found a possible correlation between the presence of slowly-rising gas rotation curves and the ratio of the bulge/disk half luminosity radii, while there is no obvious correlation with the key parameter represented by the morphological classification, namely the bulge/disk luminosity ratio. Systems with a diffuse dynamically hot component (bulge or lens) with a scale length comparable to that of the disk are characterized by slowly-rising gas rotation curves (e.g. NGC 772, NGC 980, NGC 3898). On the other hand, in systems with a small bulge the gas follows almost circular motions, regardless of the luminosity of the bulge itself (e.g. NGC 5064, NGC 7782). We noticed a similar behavior also in the gas and stellar kinematics of the two early-type spiral galaxies modeled by Corsini et al. (1998).

Acknowledgements

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