The Counter-Rotating Twin Disks in NGC 4550

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Abstract. We discuss the striking kinematic properties of the S0 galaxy NGC 4550. A detailed analysis of the line-of-sight velocity distribution (LOSVD) along the major axis shows that this galaxy contains two cold, cospatial, counterrotating disks with indistinguishable scale lengths and luminosities. The two disks, twins save the signs of their spin, are also found to have exponential luminosity profiles. We discuss qualitatively how this system might have formed.

Key words: galaxies: kinematics - galaxies: lenticulars - galaxies: individual: NGC 4550

The E7/S0 galaxy NGC 4550 was recently discovered by Rubin *et al.* (1992) to have counter-rotating, cospatial, stellar disk components. In this contribution we summarize the results of a detailed photometric and kinematic study by Rix *et al.* (1992) which quantified the striking properties of this object. The kinematics were studied by analyzing the line-of-sight velocity distribution (LOSVD) along the major axis which is reflected in the broadening of the stellar absorption line spectra (see e.g. Rix and White 1992). Outside the bulge, this velocity distribution is bi-modal, each component arising from the stars in one disk. The qualitative behavior is illustrated in Figure 1.

The Structure of NGC 4550

- The disks have identical luminosities and exponential profiles with indistinguishable scale lengths. Thus, the two disks appear photometrically to be one.
- The bulge contributes only $\sim 15\%$ to the total light, appears to be non-rotating and shows no sign of multiple components.
- Both disks are kinematically as "cold" ($v/\sigma \sim 2-3$) as normal S0 disks at one scale length.
- In both disks the velocity dispersion appears to be roughly constant over ~ 2 scale lengths, while for all other known disks the dispersion drops with radius.
- The stellar populations are old (probably at least a few Gyrs) and the galaxy appears to be in a steady state.

These properties make NGC 4550 the kinematically most unusual galaxy known!

Speculations about the Formation History

So far, no coherent, quantitative scenario of how to form a galaxy with the above properties exists.

All attempts to simulate the dissipationless formation of such a system through the merger of spirals with anti-parallel spin have failed (J. Dubinski *priv. comm.*, Heyl, Hernquist, Spergel *in prep.*) because the the simulations show that the two disks get heated too much.

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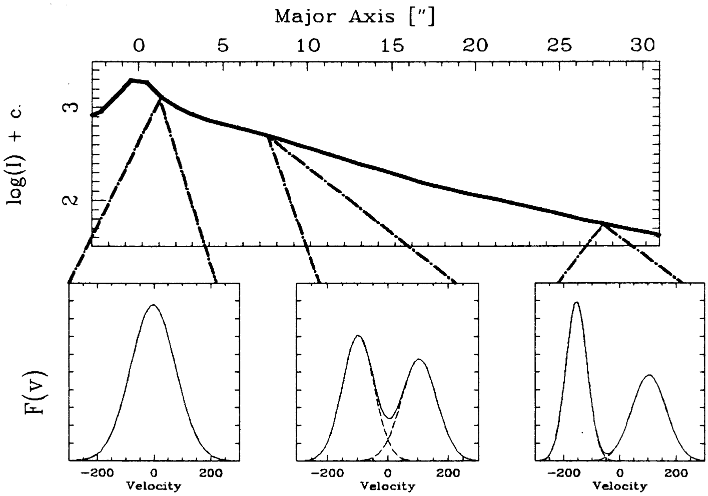

Figure 1: Major Axis Kinematics of NGC 4550
The top panel shows the major axis profiles of NGC 4550 along with the LOSVD at several distances from the center. At the center the LOSVD is close to a single Gaussian, while it is bi-modal throughout the disk, with comparable flux contributions at 7″ and 26″.

Consequently, we are led to assume that the formation of the second disk occurred through the accretion of gas, which subsequently formed stars. The advantages of this scenario are that no exact anti-alignement of the spin of the new material is required, because gas can settle dissipatively, and that an adiabatic addition of gas will not heat the pre-existing disk excessively.

Nonetheless, this scenario has a number of problems: in particular it is unclear, why the second disk also has an exponential luminosity profile and why the two scale lengths are the same. If the scale length of accreted material were determined by its initial angular momentum, such a coincidence cannot be expected.

It is likely that a massive halo is needed to prevent the adiabatic compression (and increase in v_{circ}) of NGC 4550 during the gas accretion, which would otherwise have moved the galaxy off the Tully-Fisher relation (Rubin *et al.* 1992, Bothun and Gregg 1990).

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