Dynamical analysis of elliptical galaxy halos

Andi Kronawitter (1), Ortwin Gerhard (1), Roberto Saglia (2), Ralf Bender (2)

(1) Astronomisches Institut Universität Basel,
(2) Universitätssternwarte München

1. Introduction

We report on a project to determine the distribution of dark matter and the anisotropy of the stellar velocity distribution in elliptical galaxies, from absorption line profile shapes. These kinematical data are now available up to $2-3$ effective radii. In the case of the E0 galaxy NGC 6703, the first analysed by our group (Gerhard et al. 1998), we found that at 2.6 R_e the true circular velocity is $250 \pm 40\,\mathrm{km/s}$ at 95% confidence, and that correspondingly the integrated M/L_B-ratio in $2.6R_e$ is at least $\Gamma_B \geq 5.3$, whereas the central value is $\Gamma_B = 3.3$. The velocity anisotropy in this galaxy changes from nearly isotropic in the center to radially anisotropic at $\sim R_e$, and is not well–determined at $2R_e$, where $-0.5 < \beta < 0.5$ for the allowed range of potentials. In this paper we report some results on the second galaxy investigated, the cD galaxy in Fornax, NGC 1399.

2. Data

In this analysis, photometric data are used to estimate the stellar mass distribution, and kinematic data are used to model the distribution of gravitating mass including dark matter. The photometric data are a composite of HST- (Lauer et al. 1995), CCD- (Bicknell et al. 1989) and photographic data (Schombert 1986) and go out to 75 R_e for $R_e = 42''$ (Faber et al. 1989). Since NGC 1399 is nearly round (E1) we assume spherical symmetry. In this case the deprojection of the smoothed surface brightness profile is unique. Velocity dispersions σ and Gauss-Hermite-moments h_4 were measured as described by Bender et al. (1994) to $2.3R_e$, from spectra obtained using EMMI and the NTT.

3. Analysis

The goal is to determine the best spherical potential and phase-space distribution function (DF) for NGC 1399, modelling both sets of data in a χ^2 sense. In practice, we start with a potential consisting of a luminous and a dark component, determine the best DF for this potential, and then vary the potential of the dark halo until the range of suitable potentials is determined. We use an approximate isothermal sphere model for the dark halo potential; models of this kind maximize the contribution of the luminous mass (*maximum stellar mass models*).

4. Results

Fig. 1 compares two models to the observed kinematics: one in which mass follows light, and a second with a suitable dark halo component. At large radii, both the velocity dispersion and the h_4 profile of the self-consistent model fall below the data – this is the signature of extra mass in the outer parts (Gerhard 1993). Both profiles are fit well by the halo model; in the case shown the halo core radius is $160''$ and the inferred circular velocity at the outermost data point is $v_0 = 390\,\mathrm{km/s}$. The resulting integrated M/L at $2.3R_e$ is $\Gamma_B = 12.4$, whereas the central value is $\Gamma_B = 10.3$. In either model, the anisotropy parameter β is positive, i.e. the galaxy is radially anisotropic. This confirms the trend emerging from recently published results (Rix et al. 1997, Gerhard et al. 1998, Matthias, this conference).

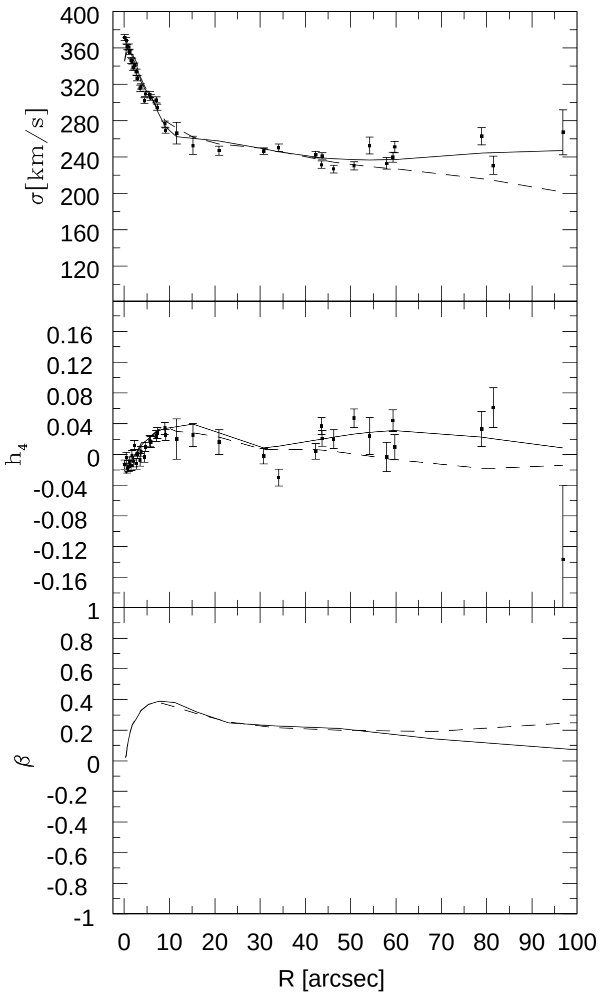

Figure 1. Comparison of constant M/L model (dashed) and a model with a dark halo (full line), to the measured velocity dispersion (top) and h_4–parameter profiles (middle panel). The bottom panel shows the intrinisic anisotropy β inferred from both models.

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