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A New Mass Modelling Trick

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1. Motivation & Methodology

The estimation of the distribution of the total (luminous and dark) mass in early type systems is hard! Even for the lucky few systems for which kinematic information is available, its implementation is mired in problems, given uncertainties about the assumptions that enter the calculations; the most critical of such assumptions involve considerations of the system geometry and the shape of its velocity ellipsoid. This work offers an independent means of getting to the mass distributions of early type galaxies, without relying directly on the phase space distribution function. The methodology is based upon the well established idea that in elliptical galaxies, the largest variations in normalised velocity dispersion profiles occur typically at $R < 0.5R_e$ ($R_e \equiv$ half-light radius) and at $R \geqslant 2R_e$.

The scheme implemented in this work is as follows: the observed brightness profile is deprojected into the luminosity density distribution along the photometric major axis (x-axis, say). This is then scaled by a two step M/L profile ($M/L(x) = \Gamma_{in}$ for $x \leqslant x_{in}$ and $M/L(x) = \Gamma_{out}$ for $x > x_{in}$). Our experiments indicate that $x_{in} = 3x_e$ where x_e is 3.33 times the reciprocal of the slope of the straight line that is fit to the core-removed surface brightness profile, plotted as a function of $x^{1/4}$, i.e. x_e is the major axis coordinate equivalent of the effective radius. The mass density distribution obtained from this scaling, is then smoothed using a triangle filter of window size corresponding to x_e. If there is a measurement of the central velocity dispersion available, (as it often is), then that can offer a zeroth-order approximation to the central mass-to-light ratio ($M/L(0)$), from a simple virial theorem estimate, which then sets a range for Γ_{in}, for a galaxy of a given shape (core radius r_c) and halo fraction (parametrised by $1/\alpha$). Constraints on the value of Γ_{out}, for a given Γ_{in} and galaxy configuration, are estimated from experiments with realistic galaxy models, and tabulated in a look-up table.

2. Results & Conclusions

Our experiments indicate that the ranges allowed for Γ_{in} and Γ_{out} overlap for test galaxies characterised by different halo fractions, as long as the constant surface brightness core does not exceed 18pc and the virial estimate of $M/L(0)$ is not rendered different from the true value, due to the degree of central anisotropy in the system, by more than a factor of about 2. For all other test configurations, this new mass modelling formalism successfully recovers one dimensional mass density profiles.

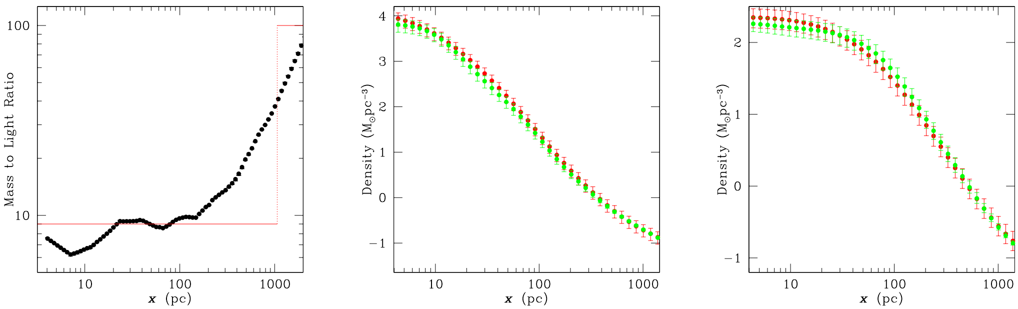

Figure 1. Left panel: The two-step M/L profile that the luminosity density is scaled by, is shown in red. The total mass density profile that results from this scaling is smoothed with a triangle filter of width x_e. The M/L profile that is indicated by this smoothed mass density is then overlaid in filled black dots, to bring out its deviation from the initial raw M/L profile. The test galaxy used here has a core radius=3.16pc and α is such that at x_e, $M/L \approx 8$. Middle and right panels: true (total) mass density distribution (in green) compared to the recovered density profile (in red) for two different test galaxies. The middle panel corresponds to r_c=3.16pc and α=2 while for the right panel, r_c=20pc and α=10.