Color dependence of the truncation of the stellar disc

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Abstract We have obtained surface brightness profiles in the near infrared (J,H,K_s) and in the optical (V) in the edge-on galaxy NGC 6504. We find profiles which gradually decrease and eventually drop to a complete cut-off, with no signs of a double exponential. The truncation radius is lower for larger wavelengths. We further notice that the magnetic model predicts a relation between the truncation radius and the constant rotation velocity at large radii, in good agreement with the observations.

In many galaxies, at large galactocentric distances, the stellar component of the disc leaves its characteristic quasi-exponential profile and becomes truncated. This truncation was discovered by van der Kruit (1979). At the truncation radius the surface brightness would become null (beyond observational limits). However this fact is still open to discussion. Erwin et al. (2005) and Pohlen and Trujillo (2006) find that a second outer exponential, usually steeper, follows the internal exponential. Bakos et al. (2008 and this volume) suggested that the break in the surface brightness profile corresponds to a change in stellar population rather than to an actual drop of stellar density. However, under the classical interpretation the profile leaves progressively the internal exponential until reaching a cut-off at R_t.

Most of our observations of truncated discs are carried out in the near infrared, more representative of the old stellar population and being less affected by extinction. We mainly use the IR-camera on the 1.5m CST telescope in Tenerife. We usu-

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ally observe edge-on galaxies and apply a numerical deprojection method. Some discrepancies between optical and NIR profiles (real truncation against double exponential) should be identified with real physical properties if the same methods would be applied to the same galaxy observed on both wavelengths ranges. Here we present observations of NGC 6504 in J, H and K_s compared with V (optical) at the 4.2 WHT in La Palma, observed with the Prime Focus Imaging Platform, PFIP.

The infrared profiles inform us that many galaxies present a classical truncation. We define the truncation curve as the difference between the real profile and the extrapolated internal exponential profile. The projection of the deprojected profile closely reproduces the original profile. The deprojected profile is different but the truncation radius remains the same. Therefore, if there is a cut-off in the original profile, a cut-off will be found in the deprojected profile.

We define the truncation curve as the difference between the real profile and the extrapolated internal exponential. A formula of the type

$$\tau(R) = (R_t - R)^{-\alpha} \tag{1}$$

reasonably fits the truncation curve where R and R_t are the galactocentric and truncation radii respectively. For α we find values around unity

Some times we find an antitruncation, i.e. the value of α becomes negative and the profile rises instead of dropping. This phenomena was discovered in the optical by the group of J. Beckman (ej. Erwin et al., 2005). We show how it can be observed in the NIR too.

A magnetic model of truncations has been proposed (Battaner et al. 2002). Magnetic and gravitational forces balance the centrifugal force in the gas dynamics. When stars are formed out of gas, the magnetic forces suddenly disappears and stars are born out of equilibrium. Some stars migrate to higher orbits, then producing antitruncations. Others escape, then producing truncations. In fact, magnetic fields are not negligible. For example the magnetic energy density in NGC 6946 is of the order of 15 μG and the magnetic energy density has a radial scale of 16 kpc, much higher than the density radial scale of only 3 kpc. In the Milky Way, in the solar neighborhood the strength is about 6 μG. Order of magnitude simple calculations indicate that these strength are not dynamically ignorable.

With this magnetic model it is found that the truncation radius should be approximately given by

$$R_t = \frac{2GM}{\theta_0^2} \tag{2}$$

where M is the visible mass of the galaxy and θ_0 is the external rotation velocity. From the Tully-Fisher relation we know $M \propto L \propto \theta_0^c$ where c has some value near 3 or 4. It is then deduced that the truncation radius should be proportional to 3 or 4. This is an theoretical prediction confirmed by the observations.

In Fig.1 we show the optical (V) and NIR (K_s) surface brightness profiles of NGC 6504 as in Florido et al. (2007). We see that there is a clear color dependence of the truncation curve. It is to be emphasized that our profile in V reaches 28.5 magnitudes/arcsec^2, a value well above any other reported observations. Neither the

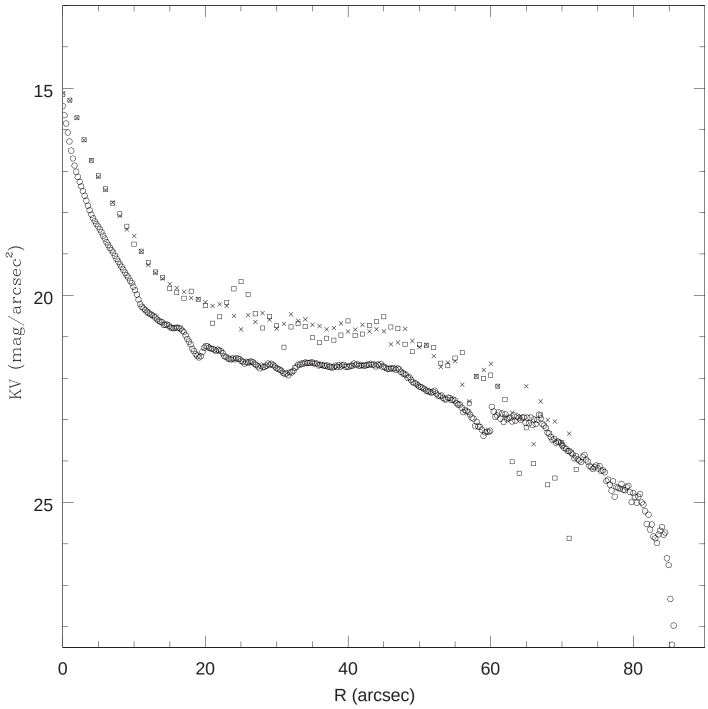

Fig. 1 V band profile of NGC 6504 (circles) comparing the eastern (squares) and the western sides (crosses) with the Ks band profiles.

optical nor the NIR profiles are well fitted by a double exponential and the truncation seems to be complete, within observational limits. The larger the wavelength the shorter the truncation radius.

References

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