Dark Matter in Galaxies
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Dust and the observed dark matter content of galaxies

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Abstract. Using detailed Monte Carlo radiative transfer modeling, we examine the effects of absorption and scattering by interstellar dust on the observed kinematics of galaxies. Our modeling results have a direct impact on the derivation of the properties of dark matter haloes around both elliptical and spiral galaxies. We find that interstellar dust has a very significant effect on the observed stellar kinematics of elliptical galaxies, in the way that it mimics the presence of a dark matter halo. Taking dust into account in kinematical modeling procedures can reduce or even eliminate the need for dark matter at a few effective radii. Dust profoundly affects the optical rotation curve and stellar kinematics of edge-on disc galaxies. This effect, however, is significantly reduced when the galaxy is more than a few degrees from strictly edge-on. These results demonstrate that dust attenuation cannot be invoked as a possible mechanism to reconcile the discrepancies between the observed shallow slopes of LSB galaxy rotation curves and the dark matter cusps found in CDM cosmological simulations.

1. Introduction

Absorption and scattering by interstellar dust in galaxies will not only affect the photometry, but all observables, including the observed kinematics. To take these effects into account, detailed radiative transfer modeling is necessary. We have developed a new Monte Carlo radiative transfer code SKIRT (**S**tellar **K**inematics **I**ncluding **R**adiative **T**ransfer). The code combines radiative transfer through interstellar dust with velocity information, such that we can use it to investigate the effects of interstellar dust on the observed kinematics of galaxies.

2. Spiral galaxies

The observed flatness of spiral galaxy HI rotation curves out to very large distances clearly demonstrates the presence of dark matter. Less clear, however, is the amount of dark matter present in the inner regions of spiral galaxies. There is a discrepancy between the observed shallow slope of dark matter haloes in LSB galaxies, and the steep slope predicted by CDM cosmological simulations.

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Important here is that the inner dark matter profiles are usually derived from Hα observations, which are subject to dust attenuation.

We have investigated whether dust can serve as a valuable explanation for this discrepancy by comparing the kinematics of dusty spiral galaxy models with similar dust-free models (Baes et al. 2003). For edge-on galaxies, there is a strong effect of dust attenuation on the rotation curve: the rotation curve becomes increasingly shallower for increasing optical depths. Edge-on galaxies with an observed shallow rotation curve could hence in reality have an intrinsically steep cusp. However, this effect is strongly reduced when the galaxies are more than a few degrees from exactly edge-on. For inclinations as large as 80°, dust attenuation is completely negligible. As a result, it cannot be invoked as a possible mechanism to reconcile the discrepancies between the observed shallow slopes of LSB galaxy rotation curves and the dark matter cusps found in CDM cosmological simulations.

3. Elliptical galaxies

Unlike spiral galaxies, ellipticals lack a clear and ubiquitous tracer for dark matter out to large radii. The existence of dark matter haloes around ellipticals is supported by X-ray temperature measurements and gravitational lensing. The most direct tracer, however, to investigate the detailed mass distribution at a few effective radii is stellar kinematics. The stellar kinematical signature of a dark matter halo is a fairly slowly decreasing dispersion profile and relatively large high-velocity wings in the line profiles in the outer parts of the galaxy. Based on such evidence, unambigous detection of dark matter around a number of elliptical galaxies has recently been claimed. Stellar kinematical data are, however, subject to dust attenuation. Although ellipticals are generally considered to be relatively dust-free, they have surprisingly large IRAS fluxes, suggesting the presence of significant amounts of smoothly distributed dust.

We have investigated how dust attenuation affects the stellar kinematics of elliptical galaxies, and how this can bias the stellar kinematical evidence for dark matter haloes around them (Baes & Dejonghe 2001, 2002). Our results show that dust attenuation (in particular scattering) has a similar effect on the observed kinematics of ellipticals as the presence of a dark matter halo: the observed velocity dispersion decreases more slowly than expected from photometry alone and the outer line profiles have significantly larger wings compared to the optically thin case. Detailed modeling shows that dust-affected kinematics will indeed be interpreted as evidence for dark matter if dust is not taken into account in the modeling procedure. Dust can hence serve as an additional or alternative way to explain the stellar kinematical "evidence" for dark matter around ellipticals.

References

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