The line-of-sight warp of the spiral galaxy ESO 123-G23

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We present 3-D modelling of the distribution and kinematics of the neutral hydrogen in the spiral galaxy ESO 123-G23. The optical appearance of this galaxy is an almost perfectly edge-on disk, while the neutral hydrogen is found to extend vertically out to about 15 kpc on either side of the galactic plane. The HI layer and the major features of the HI data cube can be successfully explained by a model dominated by a strong (about 30°) line-of-sight warp. Other models were tried, including a flare model and a two-component model, but they clearly do not reproduce the data. This is the first unambiguous detection of a galactic warp that has the maximum deviation from the central plane almost along the line-of-sight. No evidence for the presence of any companion galaxy is found in the HI data cube. Line-of-sight warps in edge-on galaxies are probably frequent, but escape detection as they are too weak. Moreover they may easily be mistaken as flares or 'thick disks'. A 3-D modelling of the HI layer as the one presented here is needed in order to distinguish between these possibilities.

Galaxies: individual (ESO 123-G23) – Galaxies: kinematics and dynamics – Galaxies: structure Introduction

The outer parts of the disks of spiral galaxies are frequently warped (Bosma bosma, García-Ruiz et al. garcia-ruiz). Warps are best seen with HI observations, since the neutral hydrogen extends out to much larger radii than the optical disk. HI warps obey some general rules, one of them being that they usually start around R_{25} (Briggs briggs). The measured angle between the inner plane and the outermost observed HI ring spans a wide range of values, from a few degrees to a few tens in some exceptional cases. Of the various possible orientations that warps can have, one is considered as "unfavourable", as the warp becomes less visible: this is when the largest deviation from the central plane occurs *along the line-of-sight*.

The origin of warps is still poorly understood. Different models have been proposed, for instance: the precession of a disk embedded in a flattened dark halo, misaligned with the disk itself (e.g. Toomre toomre), or the accretion of gas with angular momentum different from that of the disk (e.g. Ostriker & Binney ostriker), but none is completely satisfactory.

In an ongoing project to study the dark matter distribution of spiral galaxies a sample was culled from the list of Persic and Salucci (persic) selecting the best determined optical rotation curves; the selection criteria were: symmetry of the Hα rotation curve, high angular extent, high HI flux and low luminosity (Gentile et al., in prep.) The aim was to combine these optical data with HI measurements tracing the gravitational potentials much further out. One of these galaxies, the edge-on spiral ESO $123-G23$, *turned out to look remarkable in its HI distribution. Indeed the HI emission extends far away (up to about 15 kpc) from either s of−sight. We have therefore modelled the HI layer of ESO* $123-G23$ *considering these possibilities. Our analysis shows that the of − sight. The other possibilities are clearly ruled out.*

Observations

figure !fig1.eps Optical DSS image (grey scale) overlayed with the HI total intensity map of the observed data cube (top) and of the line-of-sight warp model (bottom). Contours are 1×10^{20} cm^{-2} (pseudo-3σ defined similarly to Verheijen & Sancisi verheijen), 4, 7, 10, ... $\times 10^{20}$ cm^{-2}. The HI beam is shown in the top left corner. radopt