NEUTRAL HYDROGEN DISTRIBUTIONS AND PROBABLE
MAGNETIC FIELD DISTRIBUTIONS IN NEARBY SPIRAL GALAXIES

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Abstract. Six spiral galaxies (NGC 253, NGC 2903, M 106, M 63, M 51, and M 83) are studied in their H I and magnetic field distributions. There is a possible link between the two distributions, such that a spiral-galaxy with a regularly shaped (VA = 1) or moderately arched (VA = 2) disk of neutral hydrogen seems to have a regular axisymmetric azimuthal magnetic field \( (m_{\text{azim}} = 0) \). Conversely, a spiral galaxy with a strongly arched (VA = 3) or extremely arched (VA = 4) disk of neutral hydrogen seems to have a beautifully-shaped bisymmetric azimuthal magnetic field \( (m_{\text{azim}} = 1) \).

1. Introduction

Previous work showed some statistical relation between two global parameters: the global magnetism (axisymmetric or bisymmetric) of a spiral galaxy and the global neutral hydrogen mass \( (M_{\text{H I}}) \), e.g. Vallée (1986, 1990). No obvious physical explanation of that global statistical relation \( (m_{\text{azim}}, M_{\text{H I}}) \) has been made yet.

I aim to go further than this statistical relation with the global H I gas, by investigating here the detailed distribution of the H I gas. Thus I employ a classification scheme for the shape of the H I gas distribution, i.e. the four classes of “visual archness (VA) of the radio H I distribution”. Here for the six galaxies studied, the VA classes seem to be correlated with the global H I mass.

Neutral hydrogen emission by thermal atoms undergoing a spin-flip in the disk of a spiral galaxy can reveal details of the dynamic and mass of the neutral gas, through radio observations of the 21 cm H I line. The work presented below is an attempt to relate the detailed H I distribution in a spiral galaxy to its global magnetic field’s distribution.

Section 2 uses the classification for the shape (VA) of the published detailed H I distributions in spiral galaxies. Section 3 explores possible origins of the spiral galaxies with moderately arched or regular H I disks without arching, while Section 4 does the same for the spiral galaxies with strongly arched or extremely arched H I disks. A possible correlation between VA and \( m_{\text{azim}} \) is presented in Section 5.

2. Atomic Hydrogen and VA definition

The large scale H I distribution of some spiral galaxies can be classified here. Using as input the published H I maps, my “Visual Archness” (VA) of the radio H I distribution looks for the shape of the H I distribution, as defined below.

Table I gives some details of the large scale HI distribution in six nearby spiral galaxies with a probable magnetic field shape $m_{\text{azim}}$

- VA = 1 when the HI is spread roughly circularly in the disk plane, with little or no arching. An upper limit to arches in the outer HI can be set at HI level of less than 2% of the HI levels located in the optical stellar disk of a galaxy, with linear resolution of HPBW = 2 kpc.

- VA = 2 when some moderate arching is apparent, as evidenced by some moderate tidal HI bumps, warps, bridges or rings. Some HI arches are seen in the outer HI gas at HI levels of 2% to 10% of the inner peak HI levels, for HPBW = 2 kpc. The radio arching is spiral-shaped but differs by 10 to 20 degrees of pitch angles from the inner optical stellar arms.

- VA = 3 when some strong arch in the HI disk is apparent, as evidenced by some major S-shaped HI arms just outside of the optical stellar galaxy image (not being a smooth prolongation of an optical stellar spiral arm inside the optical galaxy). The outer HI arches may have an inversed S-shaped form, opposite to the S-shaped form of the optical stellar spiral arms. The HI arches can be seen just outside the optical galaxy, at HI levels between 5% and

<table>
<thead>
<tr>
<th>Spiral galaxy</th>
<th>Magnetism</th>
<th>H I shape</th>
<th>Added note on H I gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGC 253</td>
<td>0</td>
<td>VAL92</td>
<td>1</td>
</tr>
<tr>
<td>NGC 2903</td>
<td>1</td>
<td>SOF86</td>
<td>3</td>
</tr>
<tr>
<td>M 106 = NGC 4258</td>
<td>0</td>
<td>VAL92</td>
<td>1</td>
</tr>
<tr>
<td>M 63 = NGC 5055</td>
<td>0</td>
<td>VAL92</td>
<td>2</td>
</tr>
<tr>
<td>M 51 = NGC 5194</td>
<td>1</td>
<td>BEC87; NEI92</td>
<td>4</td>
</tr>
<tr>
<td>M 83 = NGC 5236</td>
<td>0</td>
<td>SUK90</td>
<td>2</td>
</tr>
</tbody>
</table>

Ref for magnetism: BEC87= Beck et al. (1987); NEI92= Neininger (1992); SOF86= Sofue et al. (1986); SUK90= Sukumar and Allen (1990); VAL92= Vallée (1992).

Ref for H I distribution: AL86= Allen et al. (1986); BE87= Begeman (1987); BO78= Bosma (1978); CO77= Combes et al. (1977); MU83= Mulder (1983); RO74= Rogstad et al. (1974); RO90= Rots et al. (1990); SE76= Segalovitz (1976); VA75= van Albada and Shane (1975); WE73= Weliachew and Gottesman (1973); WE84= Wevers (1984); WE86= Wevers et al. (1986).