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Magnetic fields in spiral galaxies

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The magnetic field structure in edge-on galaxies observed so far shows a plane-parallel magnetic field component in the disk of the galaxy and an X-shaped field in its halo. The plane-parallel field is thought to be the projected axisymmetric (ASS) disk field as observed in face-on galaxies. Some galaxies addionionally exhibit strong vertical magnetic fields in the halo right above and below the central region of the disk. The mean-field dynamo theory in the disk cannot explain these observed fields without the action of a wind, which also probably plays an important role to keep the vertical scale heights constant in galaxies of different Hubble types and star formation activities, as has been observed in the radio continuum: At λ6 cm the vertical *scale heights* of the thin disk and the thick disk/halo in a sample of five edge-on galaxies are similar with a mean value of 300 ± 50 pc for the thin disk and 1.8 ± 0.2 kpc for the thick disk (a table and references are given in Krause 2011) with our sample including the brightest halo observed so far, NGC 253, with strong star formation, as well as one of the weakest halos, NGC 4565, with weak star formation. If synchrotron emission is the dominant loss process of the relativistic electrons the outer shape of the radio emission should be dumbbell-like as has been observed in several edge-on galaxies like e.g. NGC 253 (Heesen *et al.* 2009) and NGC 4565. As the synchrotron lifetime t_{syn} at a single frequency is proportional to the total magnetic field strength $B_t^{-1.5}$, a cosmic ray bulk speed (velocity of a galactic wind) can be defined as $v_{CR} = h_{CR}/t_{syn} = 2h_z/t_{syn}$, where h_{CR} and h_z are the scale heights of the cosmic rays and the observed radio emission at this freqnency. Similar observed radio scale heights imply a self regulation mechanism between the galactic wind velocity, the total magnetic field strength and the star formation rate SFR in the disk: $v_{CR} \propto B_t^{1.5} \propto SFR^{\approx 0.5}$ (Niklas & Beck 1997).

However, recent determination of the scaleheights in two other nearby spirals (M82 and NGC 4631) yielded different values: the scaleheights in M82 are significantly smaller than the mean values mentioned above with larger values north of the disk than south of the disk (Adebahr *et al.* 2013). The scaleheights for both, the thin and thick disk in NGC 4631 vary strongly within the galaxy, being significantly larger in some areas than the mean values (Mora & Krause, in prep.). Both galaxies show -different from the other five galaxies- strong signs of tidal interaction like HI tails and bridges (Yun *et al.* 1993, Rand 1994) where M82 might even have lost its outer HI disk by tidal disruption. Hence, from present observations of edge-on galaxies we can conclude that while star formation and even starbursts in the disk alone do not significantly change the scaleheights of the disk and halo, (strong) tidal interactions may well modify these parameters.

References

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