Can we observe reconnection heating in spiral galaxies?

M. Weżgowiec (1), M. Ehle (2), R.-J. Dettmar (3), R. Beck (4), M. Soida (1), and M. Urbanik (1)

(1) Obserwatorium Astronomiczne Uniwersytetu Jagiellońskiego, Kraków, Poland
(2) ESA-ESAC, Madrid, Spain
(3) Astronomical Institute of the Ruhr-University Bochum, Bochum, Germany
(4) Max Planck Institut für Radioastronomie, Bonn, Germany

In some spiral galaxies the so-called „magnetic arms" have been reported, being interarm areas with significant polarized radio emission and thus highly ordered magnetic fields. The most prominent example of such a galaxy is NGC6946. The nature of these magnetic features is still under debate. One of the explanations is the reconnection heating that converts the energy of the magnetic field into thermal energy of the surrounding gas. From the analysis of the radio and X-ray emission from NGC6946 we conclude that we might see hints for such reconnection heating (cf. Weżgowiec et al. 2016, A&A, 585, 3). A similar case we are likely seeing in another spiral galaxy with „magnetic arms" - M83. Almost identical parameters of the interarm magnetic fields are accompanied by slight increases in the internal energy of the hot gas.

The grand-design face-on spiral galaxy NGC6946 shows high star formation activity and the „magnetic arms", located *between* the optical spiral arms (Fig. 1). For both star-forming and interarm regions we used XMM-Newton X-ray observations to derive electron densities and temperatures and the radio polarimetry observations to estimate the strengths and energies of the magnetic field.

In the magnetic arms we found

- higher energies per particle ($E_P = \varepsilon/n$; Table 1)
- slight increases in temperature of the hot gas
- lower strengths and energies of the total B-field (Table 1)
- higher ordering of the B-field (B_{reg}/B_{tot})

This could be caused by reconnection, that

- removes some of the turbulent B-field component → regularity increases
- converts the B-field energy into thermal energy of the ISM → the gas is heated

We are now analysing the X-ray and the radio data for M83 (Figs. 2 and 3) to search for similar fingerprints of the reconnection heating.

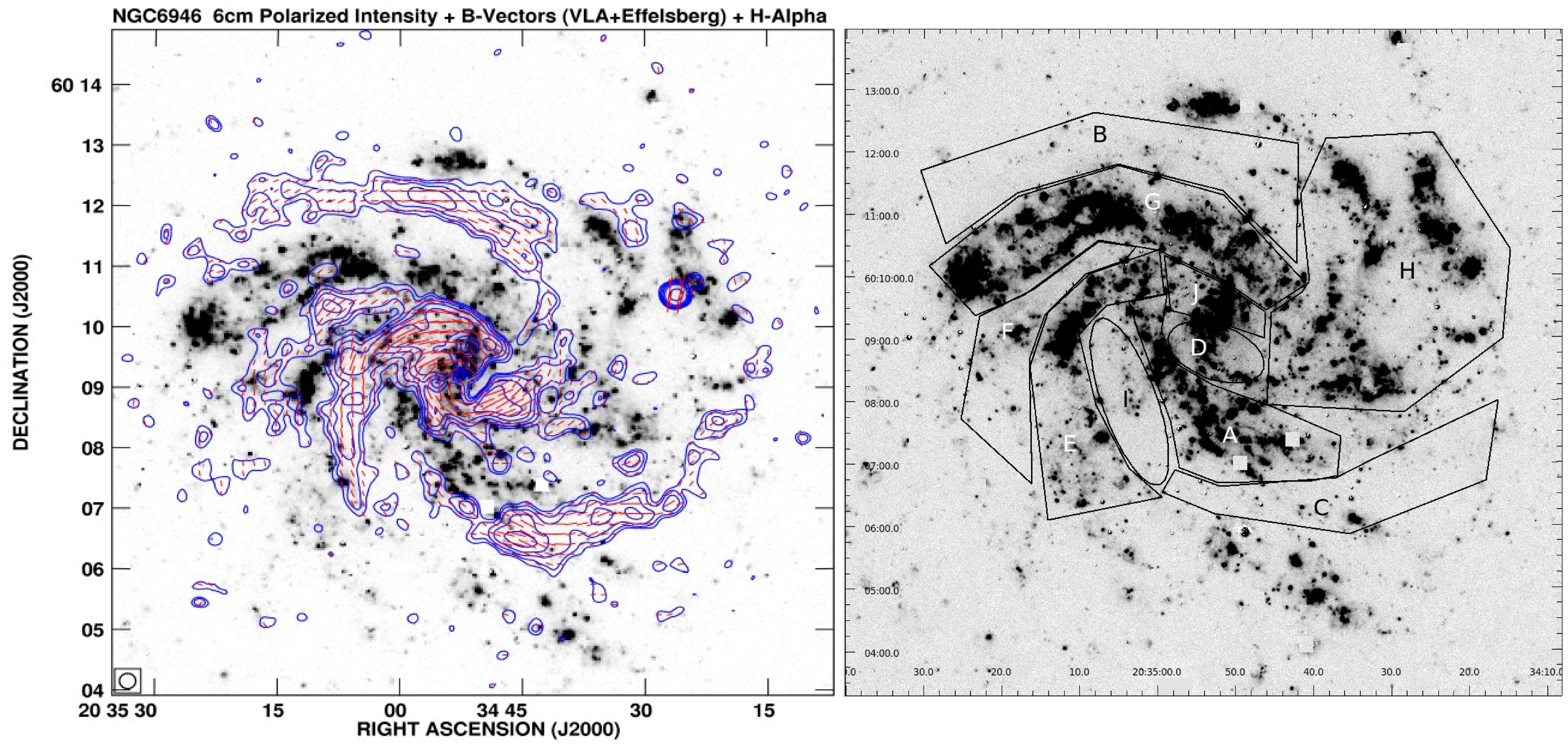

Fig. 1. Hα image of NGC6946 overlaid with contours of radio polarized intensity and vectors of the magnetic field at 4.85 GHz (left, from Beck 2007, A&A, 470, 539) and regions used in the spectral analysis of the X-ray emission (right).

Spiral arm	E_p	ϵ_B	Magnetic arm	E_p	ϵ_B
A	$0.89^{+0.10}_{-0.11}$	11.8 ± 7.1	B	$1.45^{+0.14}_{-0.15}$	8.3 ± 5.0
E	$0.95^{+0.14}_{-0.12}$	9.1 ± 5.5	C	$1.33^{+0.23}_{-0.27}$	7.6 ± 4.6
G	$0.87^{+0.08}_{-0.09}$	10.6 ± 6.4	F	$1.28^{+0.15}_{-0.16}$	8.8 ± 5.3
H	$0.88^{+0.06}_{-0.08}$	8.9 ± 5.3	I	$1.20^{+0.34}_{-0.31}$	8.2 ± 4.9

Table 1. Comparison of energies per particle in the hot gas with energy densities of the magnetic field in the studied regions of NGC6946.

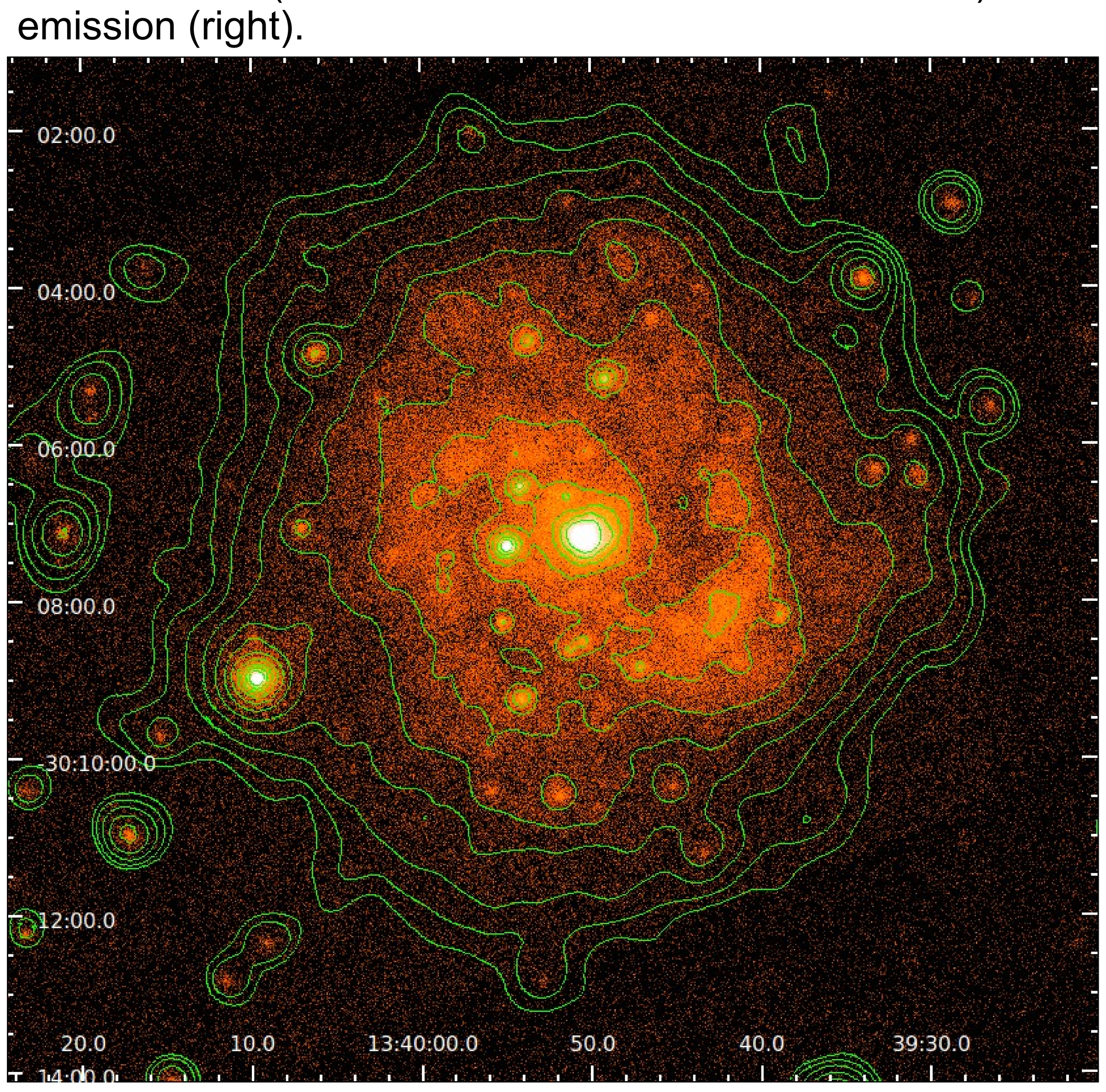

Fig. 2. XMM-Newton EPIC count image of M83 with contours of the same image adaptively smoothed with the largest scale of 30 arcseconds and the signal-to-noise of 30.

The analysis of the data is more difficult due to the lower contrast in the distribution of star-forming regions between the spiral arms and the interarm regions (compare right panels of Figs. 1 and 3).

Our studies of the regions of the magnetic arms of M83 suggest similar results as for NGC 6946:

- energies per particle comparable or slightly higher than in the spiral arms
- higher ordering of the B-field (B_{reg}/B_{tot})
- lower strengths and energies of the total B-field

This can be, again, explained with reconnection heating.

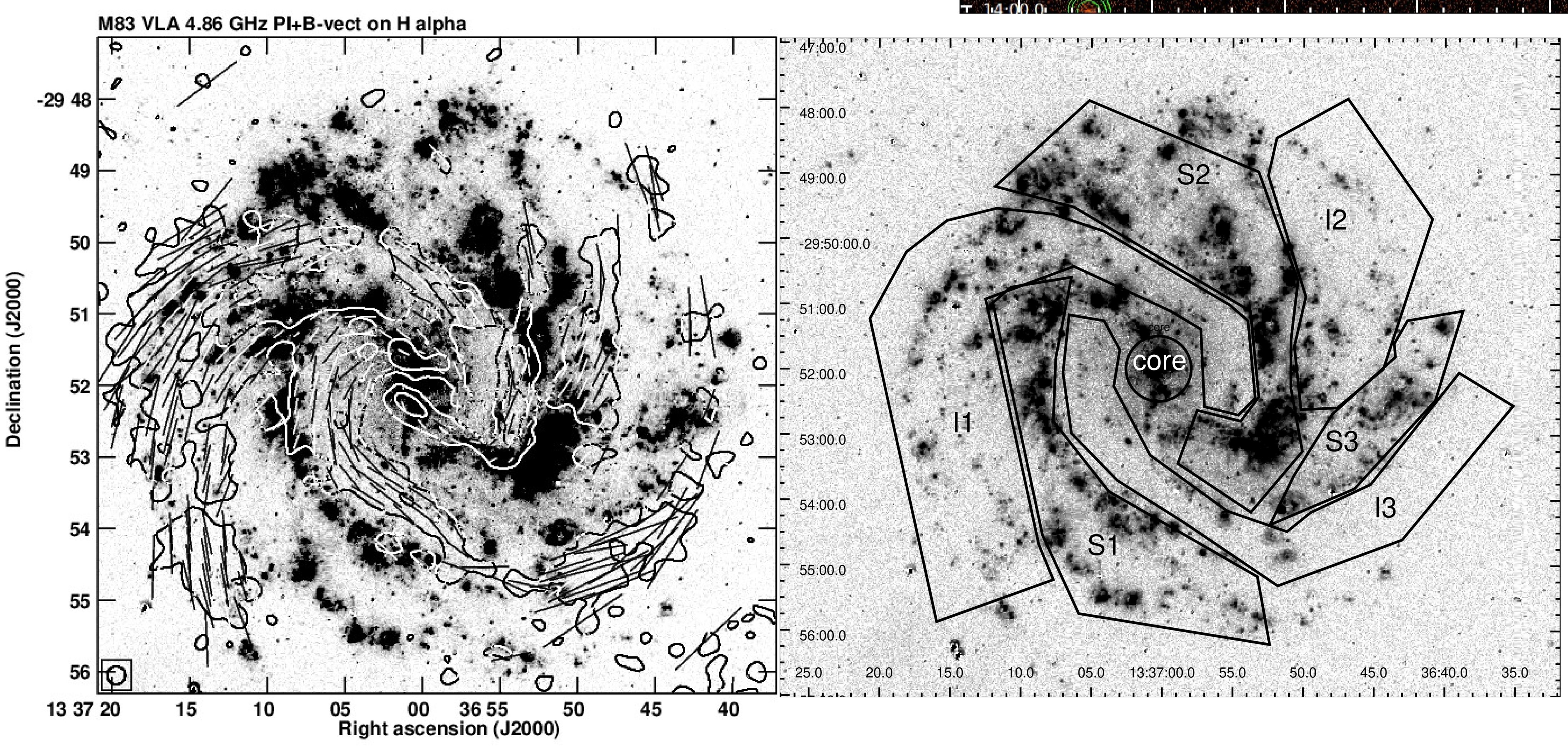

Fig. 3. Hα map of M83 overlaid with contours of radio polarized intensity and the magnetic field vectors at 4.86 GHz (left) and regions used in the spectral analysis of the X-ray emission (right).

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