Magnetic fields in galaxies at high redshifts

Martin Bernet, ETH Zürich

Francesco Miniati, ETH Zürich

Simon Lilly, ETH Zürich

Philipp Kronberg, LANL

Miroslava Dessauges, Obs. de Genève

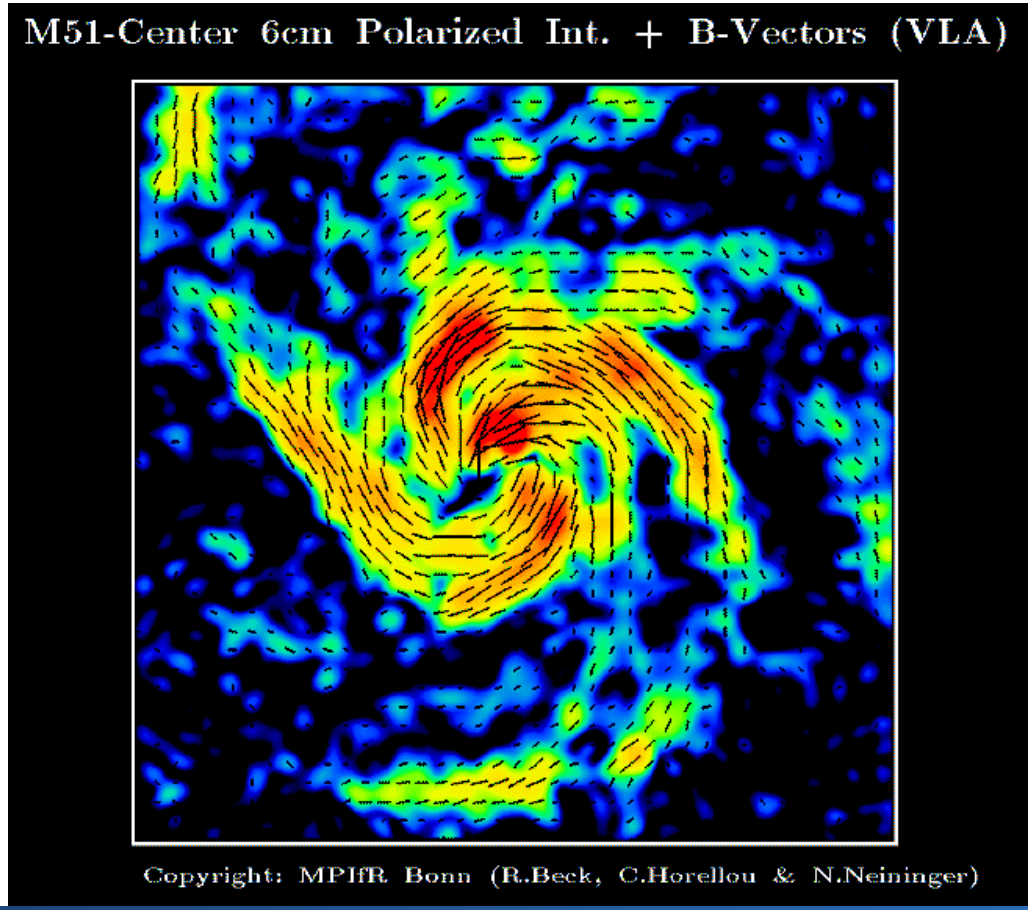
Outline

- What we know and how we know about magnetic fields in high redshift galaxies
- Analysis of RM distribution with z, *Kronberg,Bernet,Miniati,Lilly, (2008)*
- New spectra from UVES/VLT: Association between MgII absorption and enhanced Faraday Rotation

What we know about magnetic fields in galaxies (at high redshifts):

- Large scale magnetic fields are observed in nearby galaxies at μGauss level coherent over several kpc.
- Few constraints on the origin and evolution of the magnetic fields in galaxies. It is normally assumed that weak seed fields are amplified by a dynamo over time.

MPIfR:Beck,Horellou,Neininger



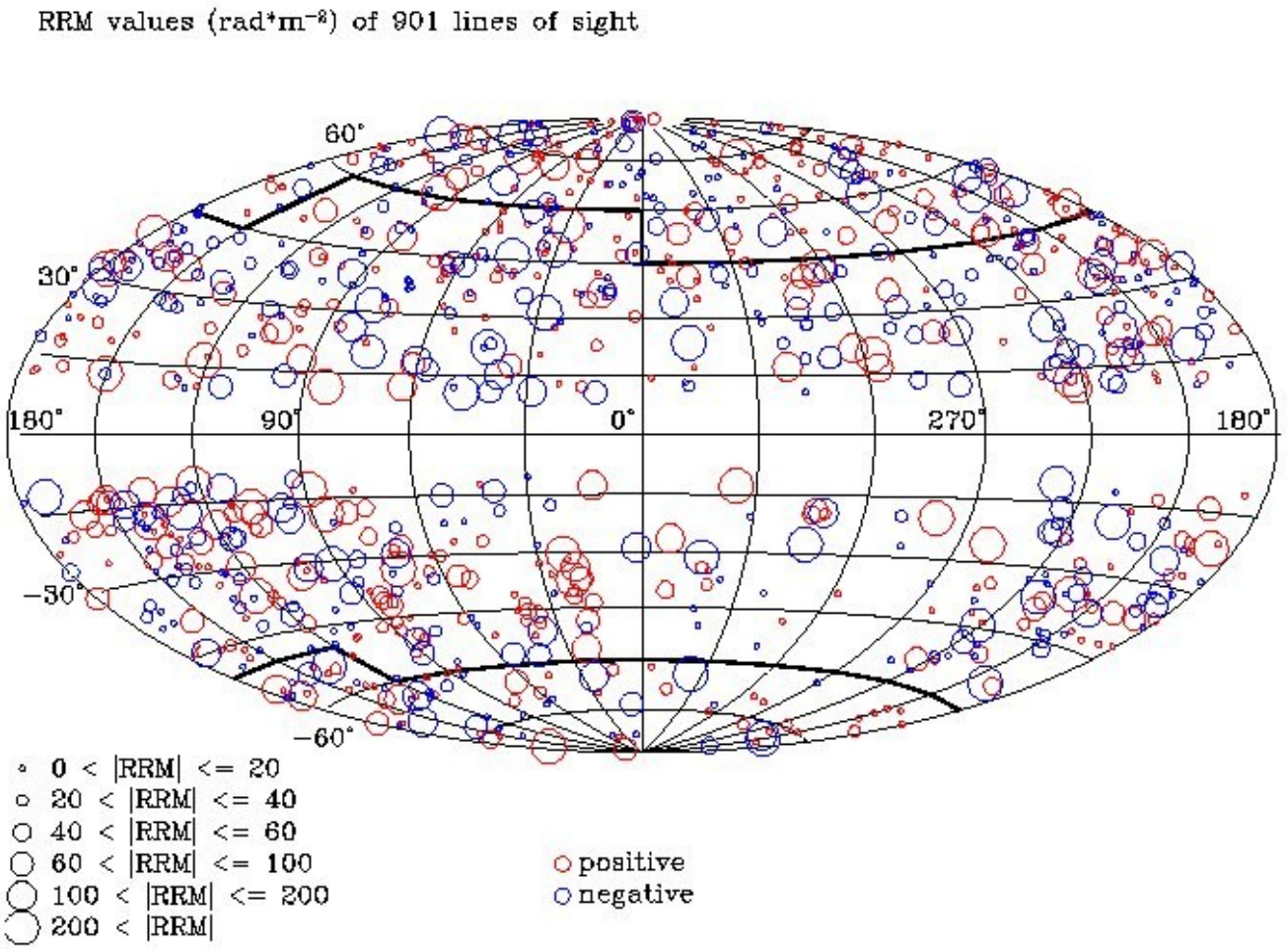
How we know about magnetic fields in galaxies at high redshifts:

- Through Faraday Rotation of polarized radio waves of distant quasars.

$$RM(z_s) = \frac{\Delta\chi_0}{\Delta\lambda_0^2} = 8.1 \cdot 10^5 \int_0^{z_s} \frac{n_e(z) B_{\parallel}(z)}{(1+z)^2} \frac{dl}{dz} dz$$

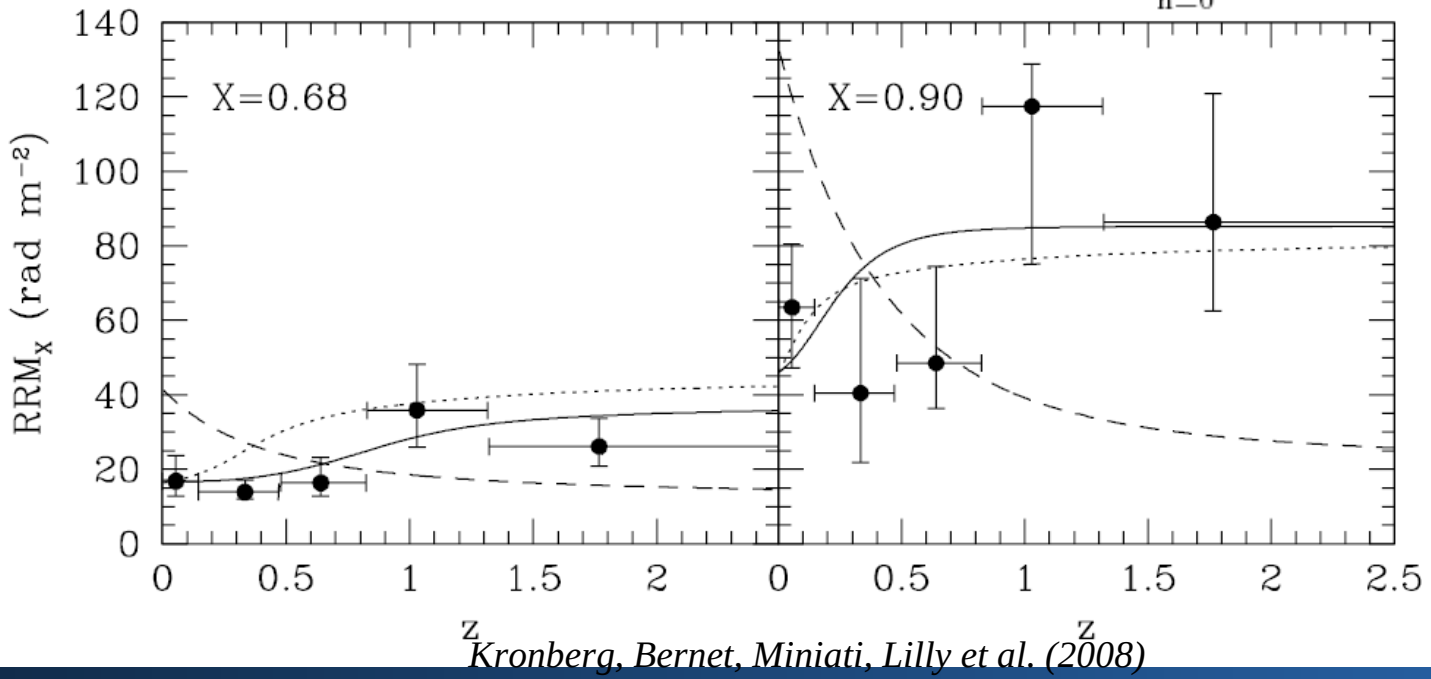
Analysis of RRM distribution with z: (RRM=RM-GRM)

- Sample of 268 sources at high galactic latitudes, $|b|>45°$



- Increase in RRM dispersion with z
- KS-test: RRM distributions at $z_s > 1$ and $z_s < 1$ are different at 3
- Simple model for RRM distribution: Galactic contribution, contribution by intervening systems modelled by dN/dz of MgII absorbing systems and intrinsic contribution:
- Pdf for observed RM is convolution of different contributions:

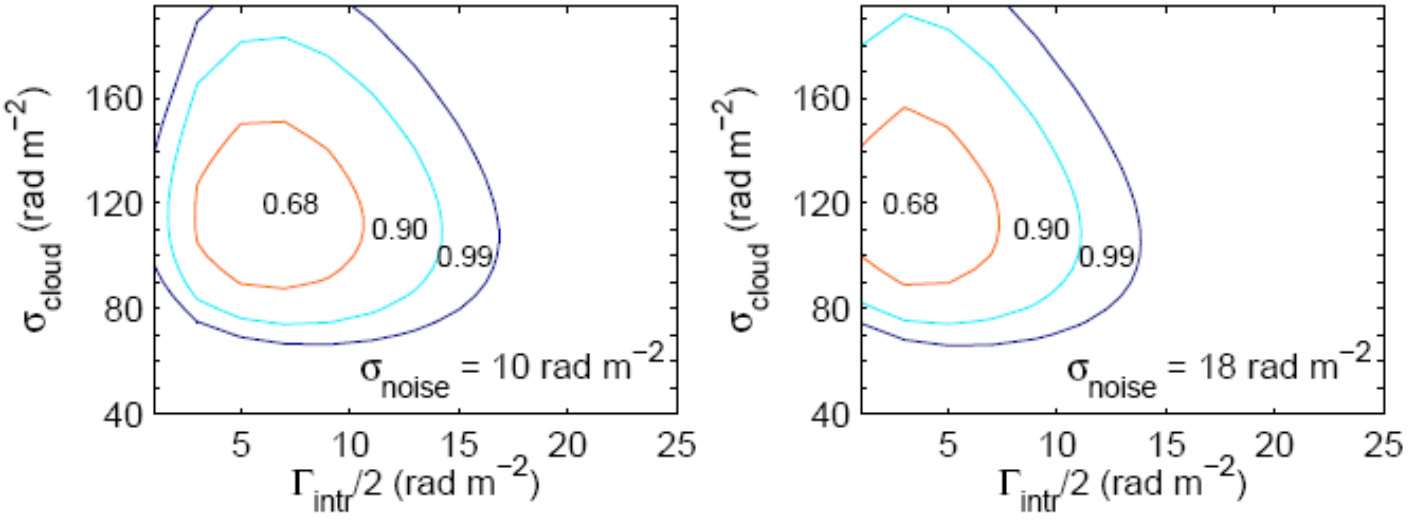
$$P_n(\mathrm{RRM}, z_s) = P_{noise} * P_{n,interv}(z_s) * P_{intr}(z_s), \qquad P(\mathrm{RRM}, z_s) = \sum_{n=0}^{n_{max}} q_n(z_s) P_n(\mathrm{RRM}, z_s)$$



Kronberg, Bernet, Miniati, Lilly et al. (2008)

- Maximum Likelihood fit gives best fit parameters:

$$\sigma_{cloud} = 115^{+45}_{-30}\ rad\ m^{-2}$$
$$\sigma_{noise} = 9^{+4}_{-2}\ rad\ m^{-2}$$
$$\Gamma_{intr}/2 = 7^{+6}_{-4}\ rad\ m^{-2}$$



Kronberg, Bernet, Miniati, Lilly et al. (2008)

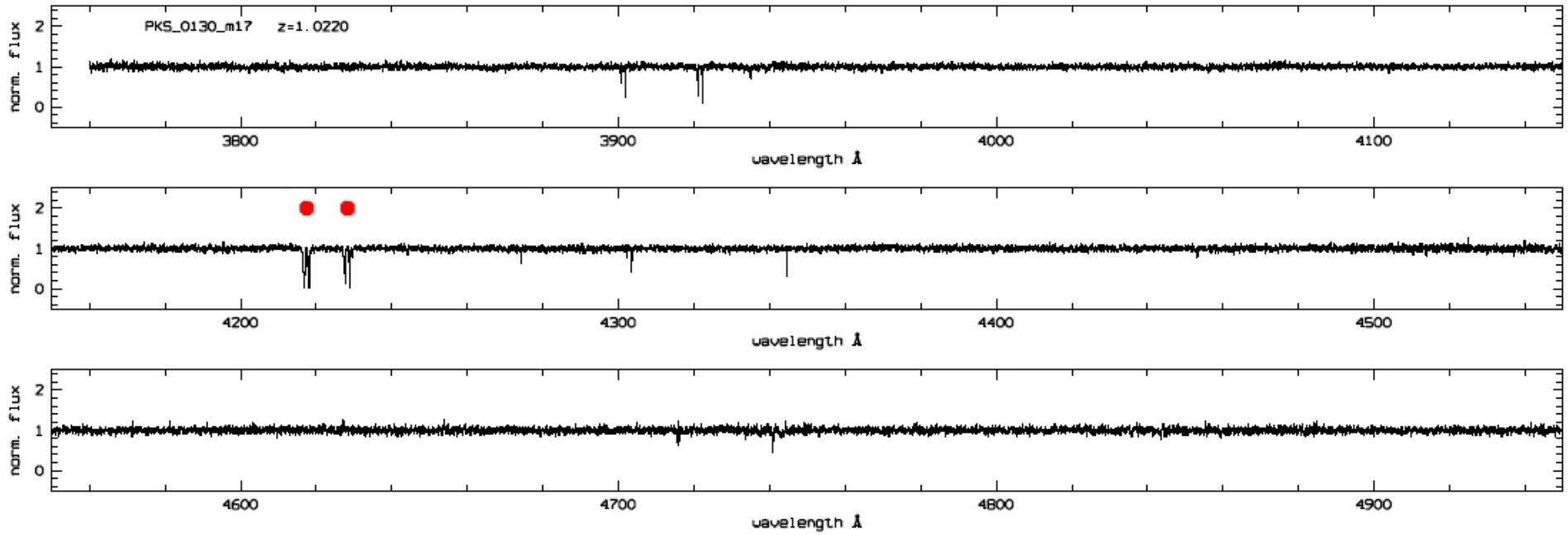
Earlier studies indicating a connection between the presence of QSO absorption lines and enhanced Faraday Rotation:

- *Kronberg, Perry (1982)* found indications that l.o.s having absorption lines ($0.4 < z < 2.8$) have broader RRM distributions than those without. Limited by heterogenous data set: various absorption lines, incomplete z coverage
- In a statistical analysis of 116 RMs from QSOs *Welter, Perry, Kronberg* (1984) found increase in RRM variance with z ($0.1 < z < 2.4$).
- *Oren,Wolfe (1995)* found that RMs from 11 known DLA system ($0.4 < z < 3.4$) have higher incidence of high RM values compared with an unbiased control sample of 50 RMs. KS-test: RM distribution different at 72% . No increase in RRM dispersion with z.

New observations to get census of intervening systems along the l.o.s to QSOs:

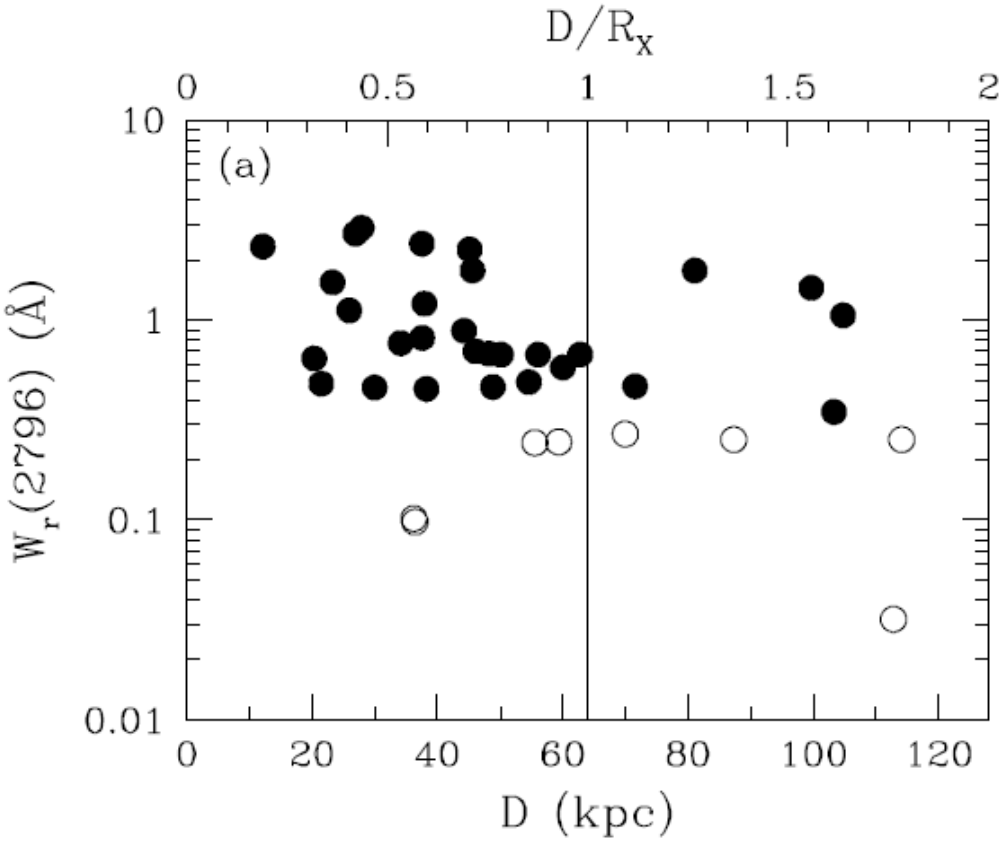
- 6 nights at UVES/VLT, R=43000, =0.1Å, v=7km s^{-1}
- Selection: $0.6 < z_s < 2.0$, $|b| > 30°$, $m_V < 19$
- 76 QSOs observed
- Complete census of strong (EWr > 0.3Å) MgII absorption lines; $\lambda_r = 2796.4, 2803.5$

corresponds to $0.35 < z < 2.2$



What are strong (EW_r > 0.3Å) MgII absorption system?

- Absorption occurs in halos of „normal“ galaxies with a covering factor ~ 1 out to 55 kpc, *Steidel et al. (1994)*
- More recent works show MgII absorption out to 100 kpc with a more patchy gas distribution, *Kacprzak et al. (2008)*
- Broad range of luminosities (0.1-3.0 L^*) and colors. Average color is consistent with that of an Sb spiral.



Kacprzak et al. (2008)