The role of Magnetic Fields in the SMBH Environment

Antxon Alberdi (IAA, CSIC)

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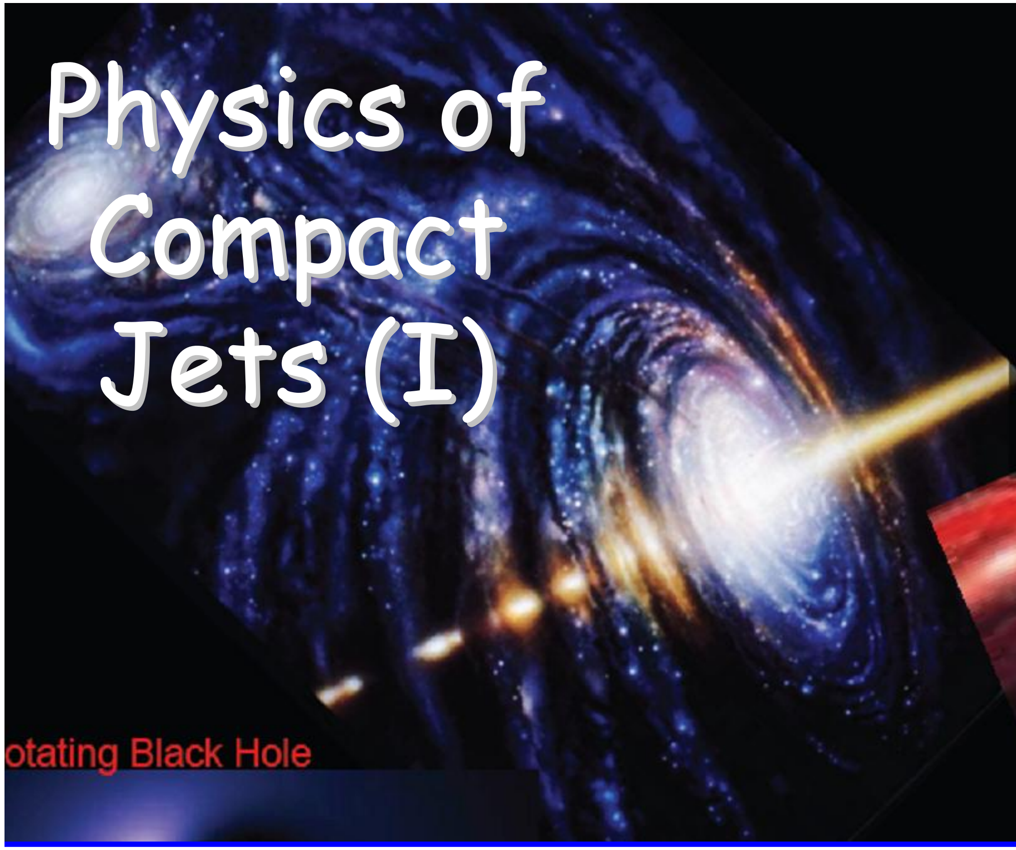
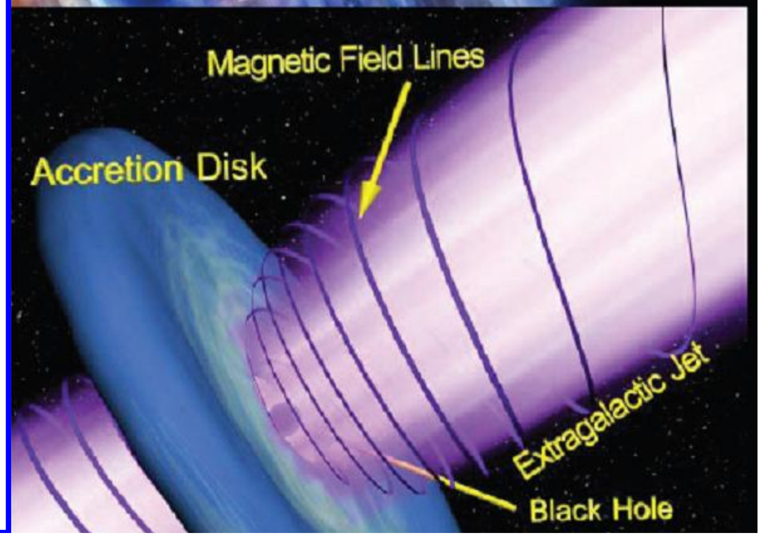
Physics of Compact Jets (I)

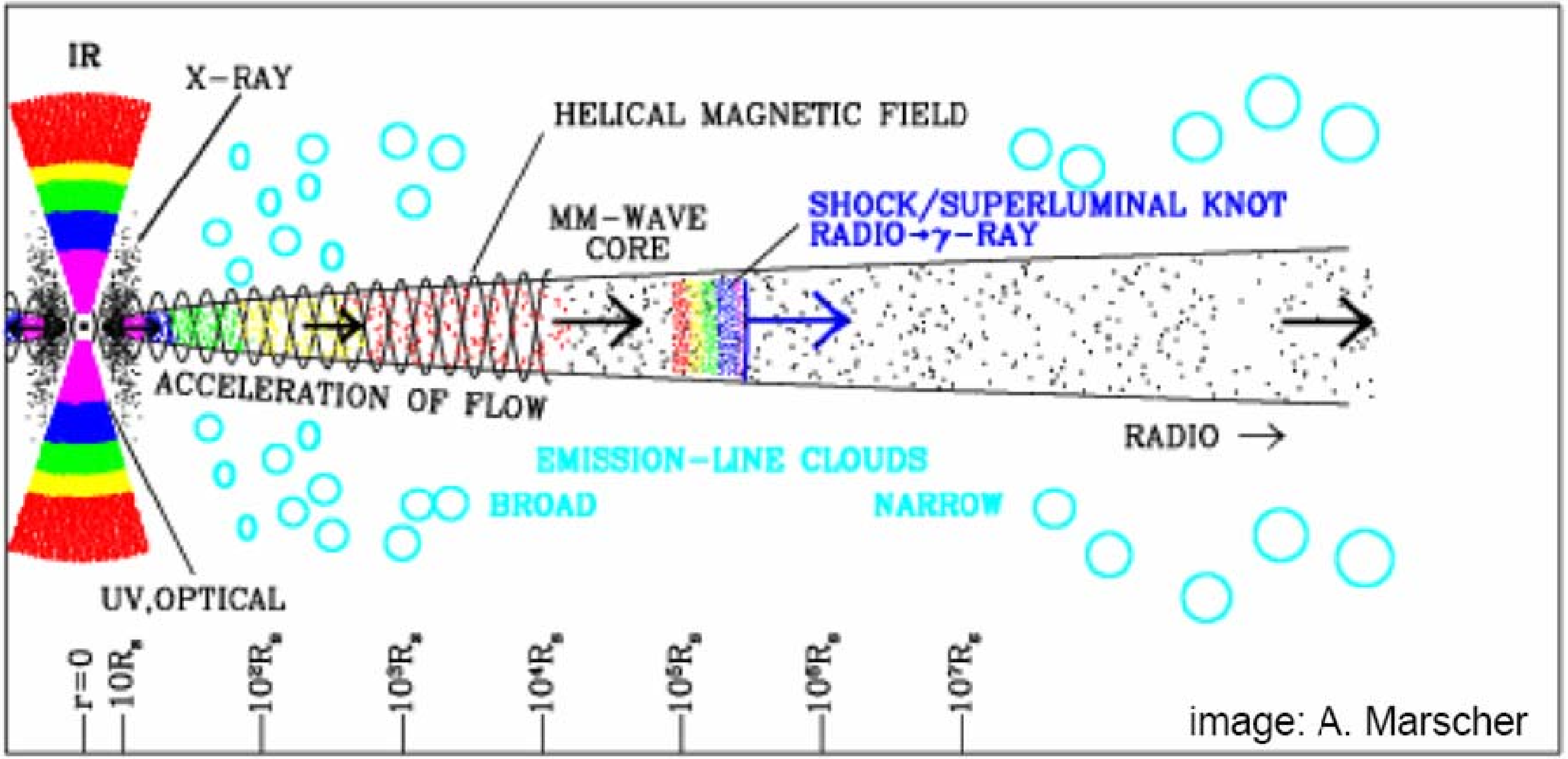


Main Motivation: What are the procceses acting at the centers of Quasars (AGN) ? How are the powerful jets launched and accelerated ?

- Jets are formed in the inmediate /icinity of the SMBH
- The collimation of such a jet ·equires either a large scale poloidal nagnetic field threading the disk or a :lower and more massive MHD outflow aunched at larger disk radii

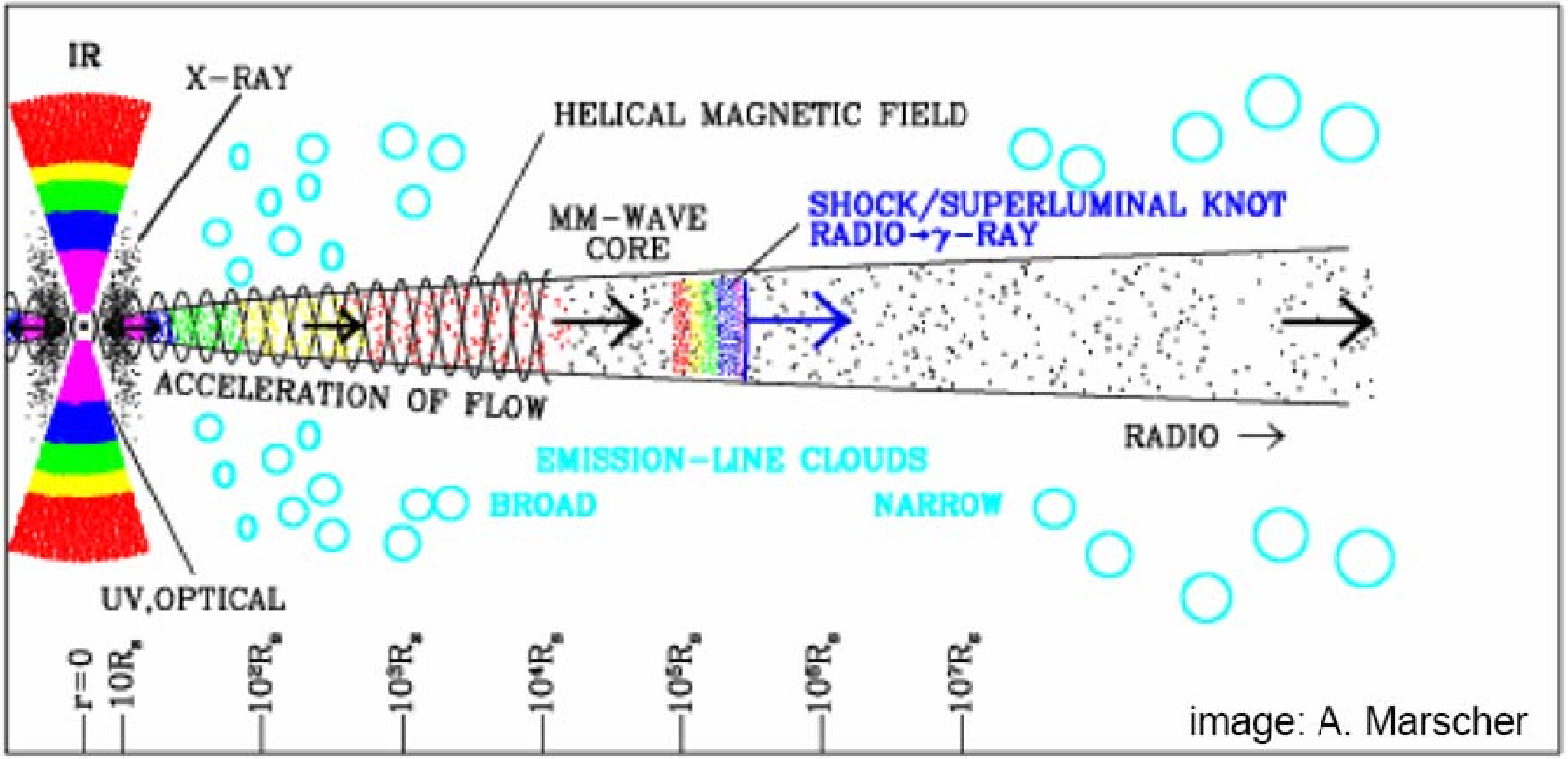


Physics of Compact Jets (II)



- Acceleration and collimation is completed around 1000 Rsch
- The magnetic field is believed to play an important role in accelerating and collimating extragalactic jets on parsec-scales

Physics of Compact Jets (III)



- Region 1: ultra-compact jets (< 1 pc) → collimation + acceleration
- Region 2: parsec-scale flows (~10 pc) → Relativistic Shocks
- Region 3: larger-scale jets (~100 pc) → plasma instabilities dominate

Physics of Compact Jets (III)

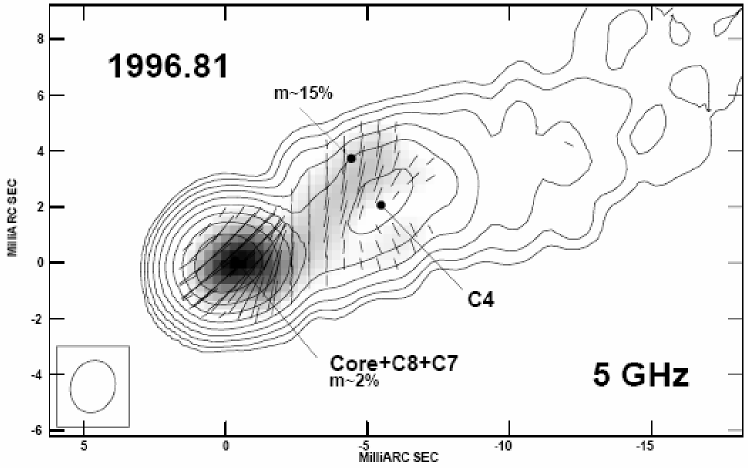
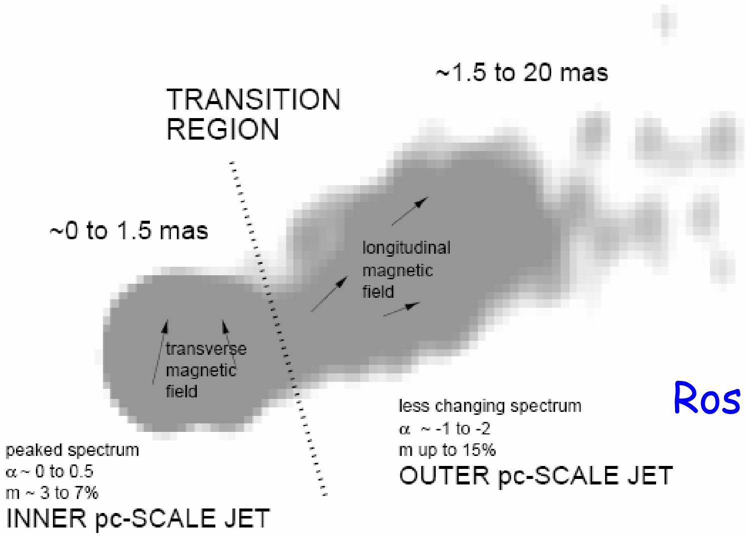


Fig. 12. Polarized intensity electric vectors (χ, length proportional to p, 1 mas in the map is equivalent to 10 mJy/beam) overlaid on total intensity (I) contours (3 mJy/beam$\times$ $-1, 1, 2.24, 5, 11.18, 25, \ldots$) and grey scale polarized intensity (p, grey scale up to the peak of brightness, 40.5 mJy/beam) images for 3C 345 at 5 GHz, epoch 1996.81. It is obvious that the electric vector is almost perpendicular to the jet at core separations from 3 to 7 mas.

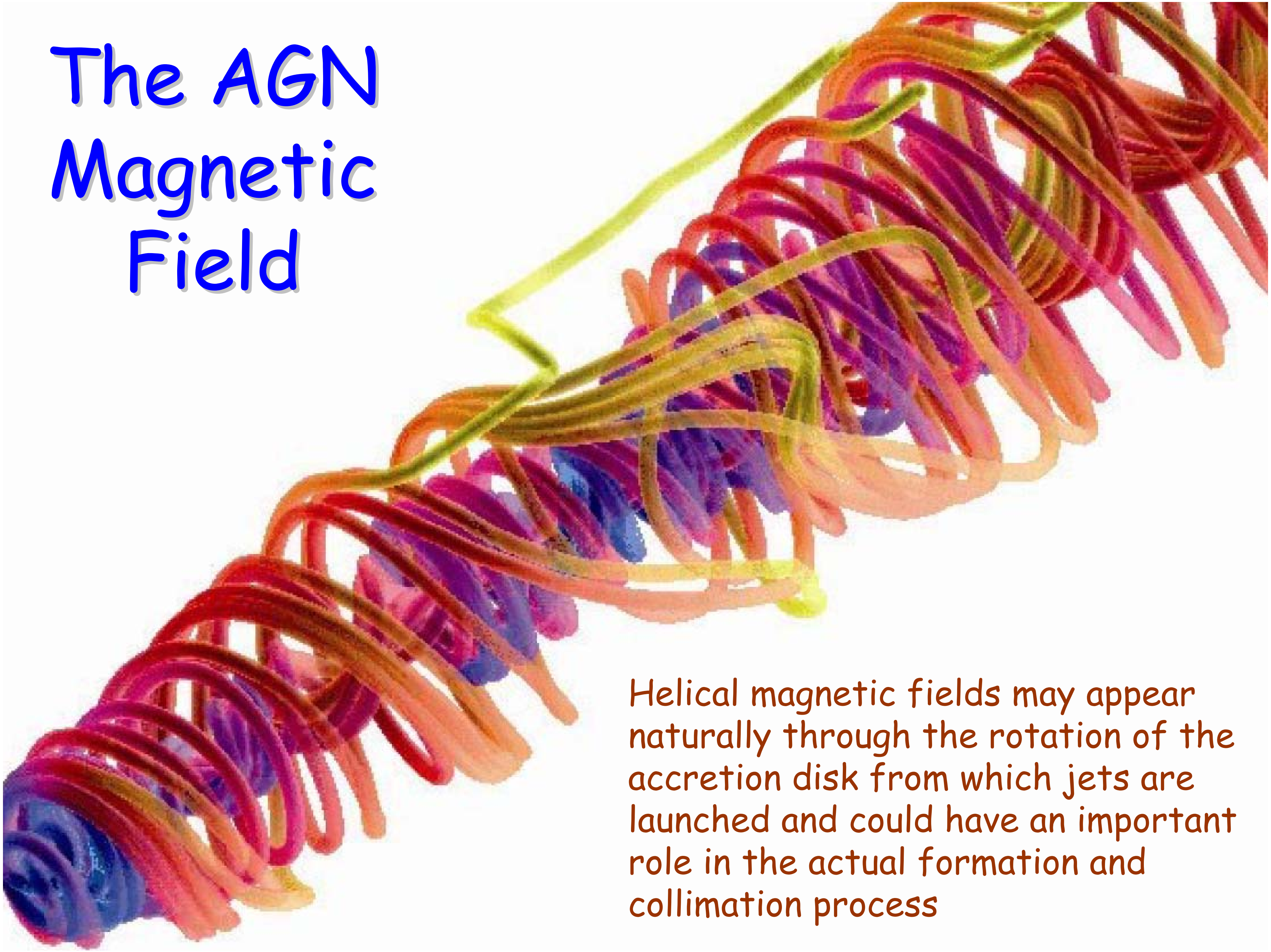


Ros et al. *A&A* 354, 55 (2000)

Fig. 13. Summary of physical properties observed in the two regions of the parsec-scale jet of 3C 345. The values for α and m refer to our four observing frequencies (5, 8.4, 15, and 22 GHz), in general.

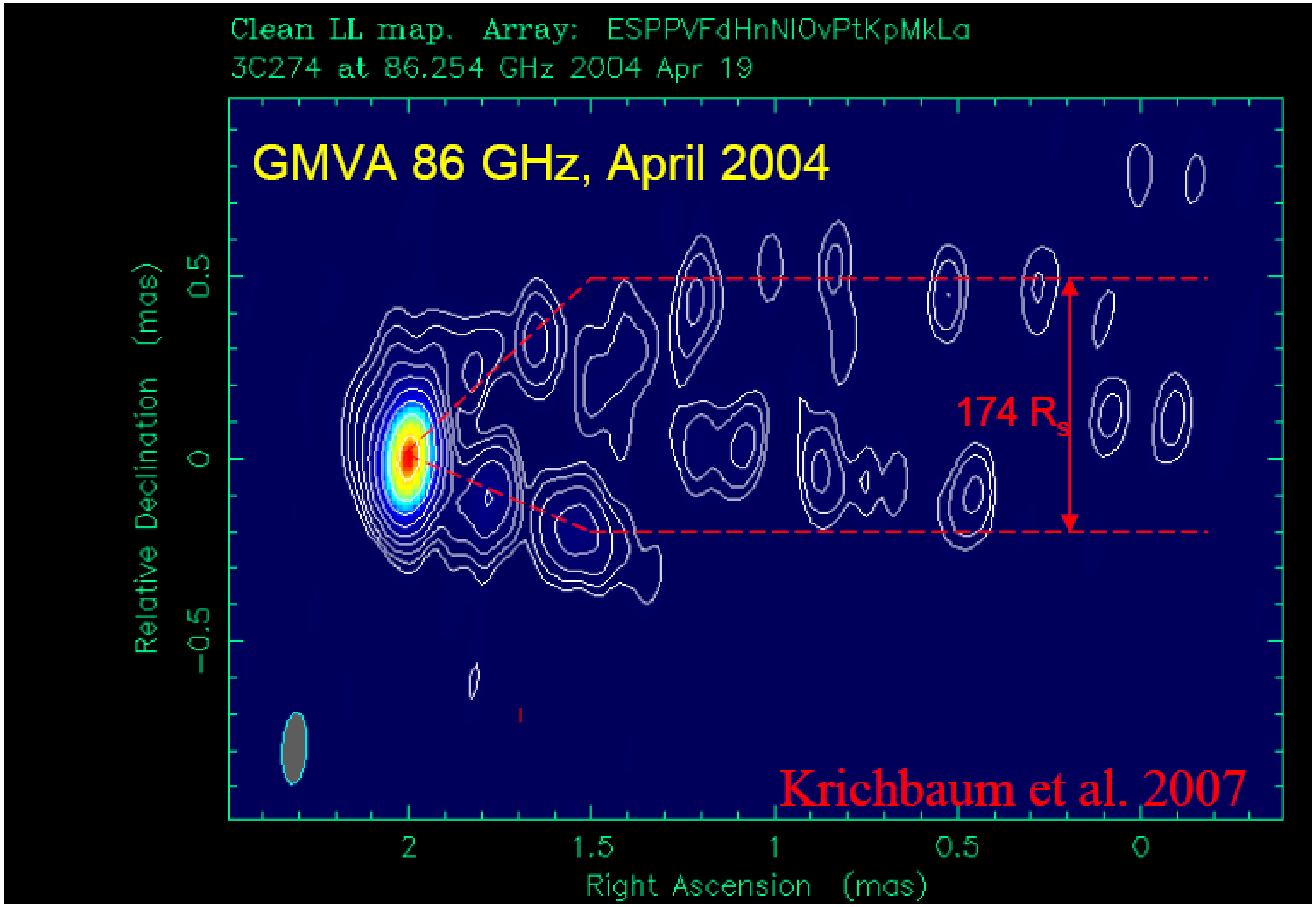
- Region 2: parsec-scale flows (~10 pc) → Relativistic Shocks
- Region 3: larger-scale jets (~100 pc) → plasma instabilities dominate

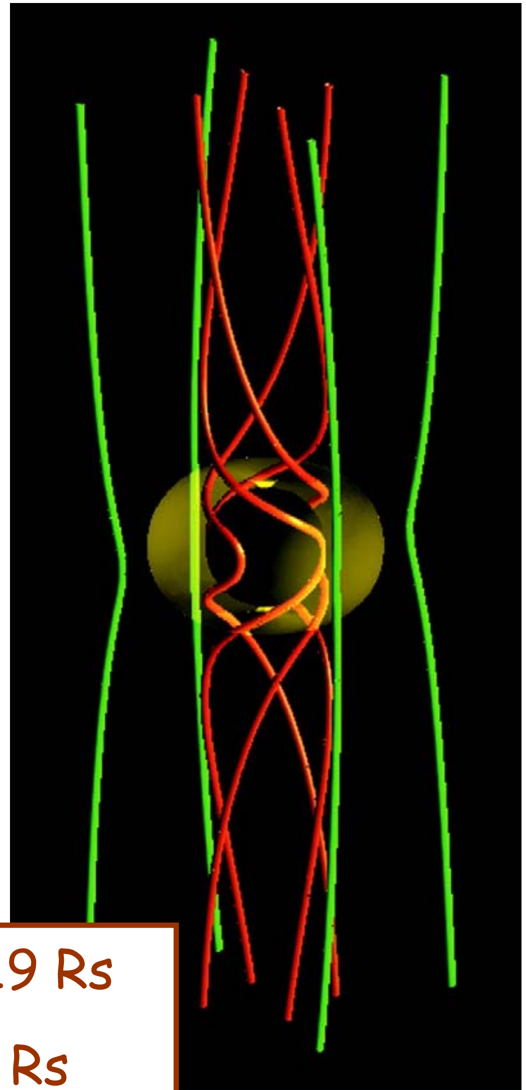
The AGN Magnetic Field



Helical magnetic fields may appear naturally through the rotation of the accretion disk from which jets are launched and could have an important role in the actual formation and collimation process

M87: the jet at 86 GHz



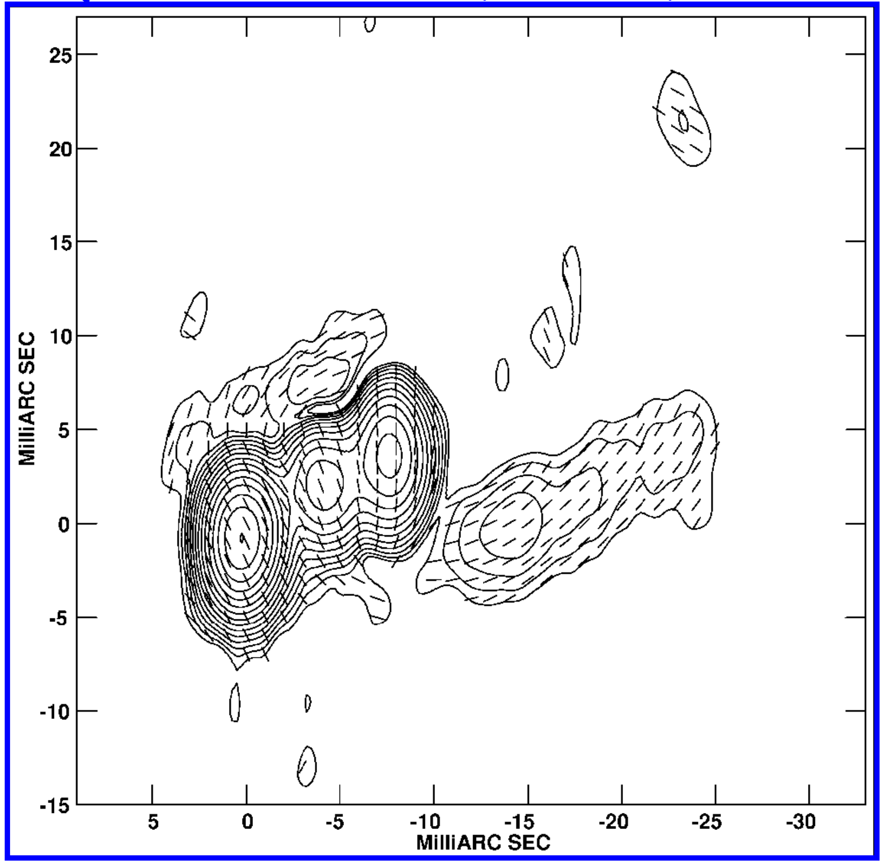


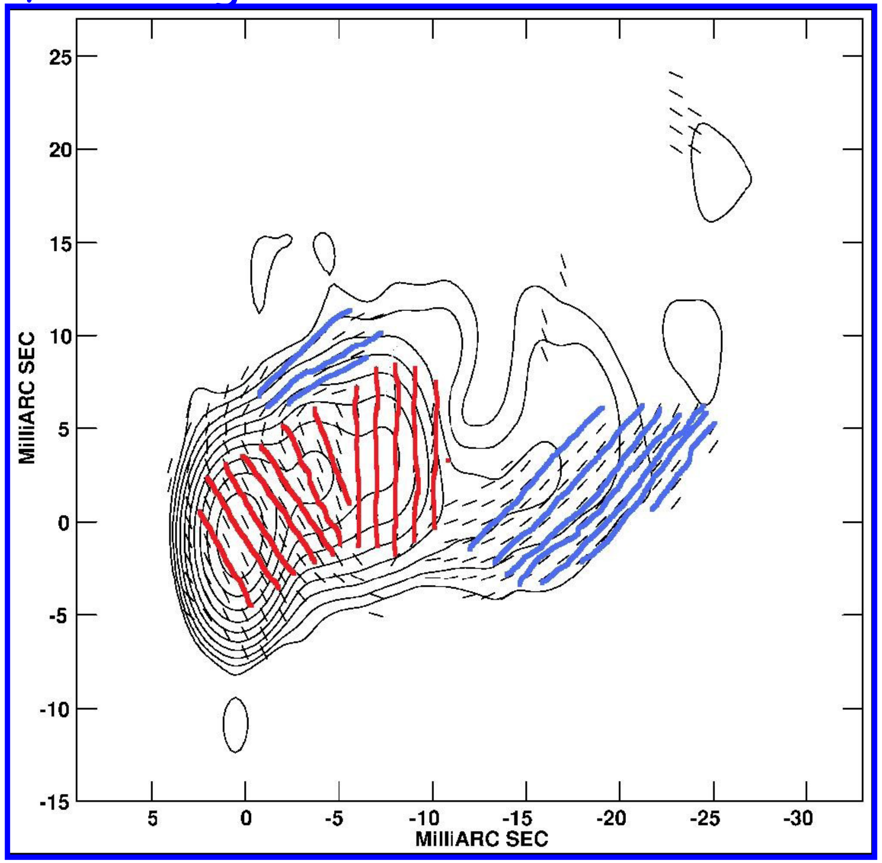
- ❑ Jet base: 197 x 54 µas = 21 x 6 light days = 69 x 19 Rs
- ❑ Bifurcation confirmed: jet-width at 0.5 mas: ~174 Rs

→ It favours models in which the jet is attached more directly to the rotating BH (not to the accretion disk)

Spine-Sheath Polarization Structure

Quasar 1055+018, 5 GHz, VLBA+Y1, Attridge et al. 1999

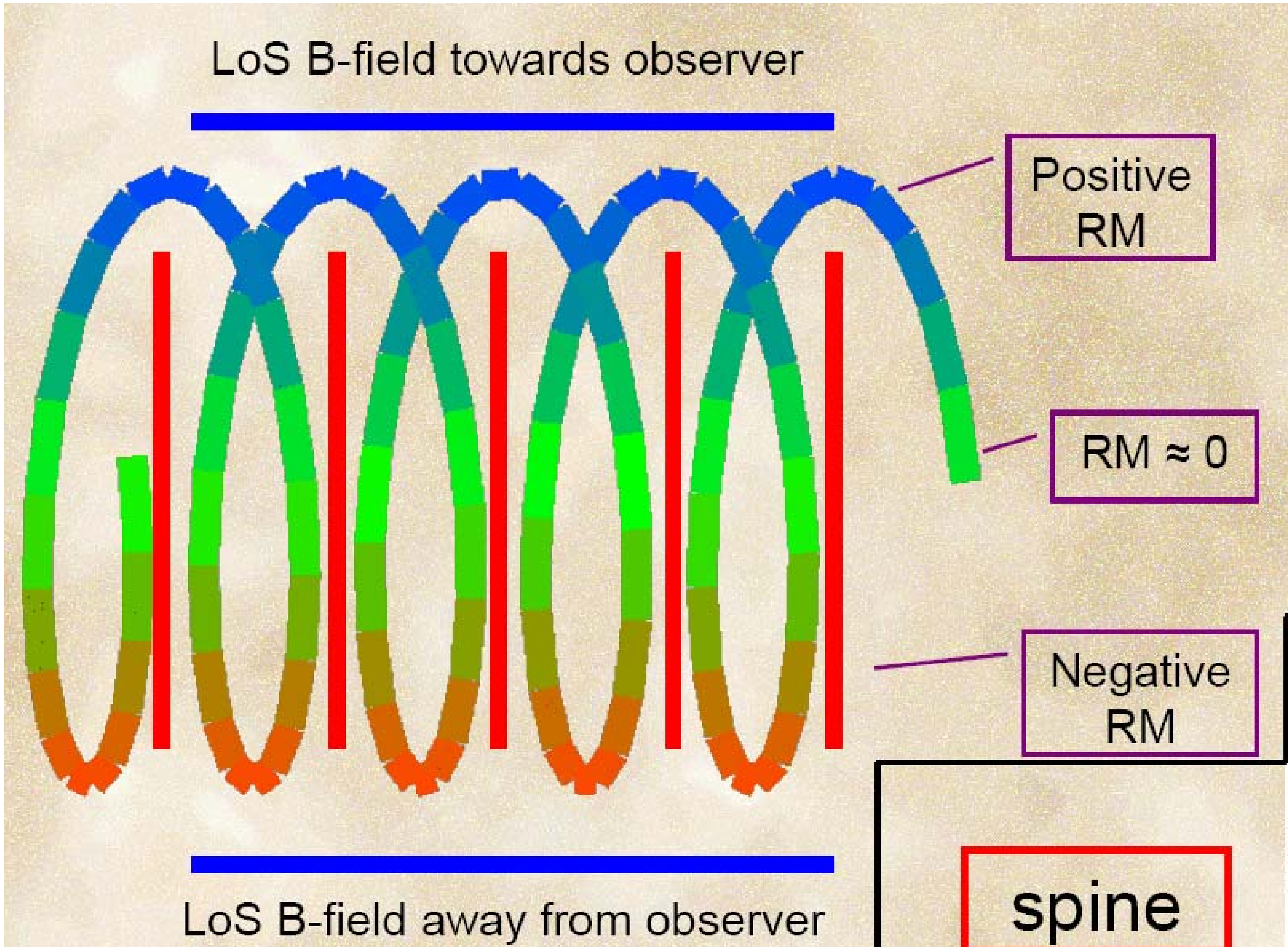




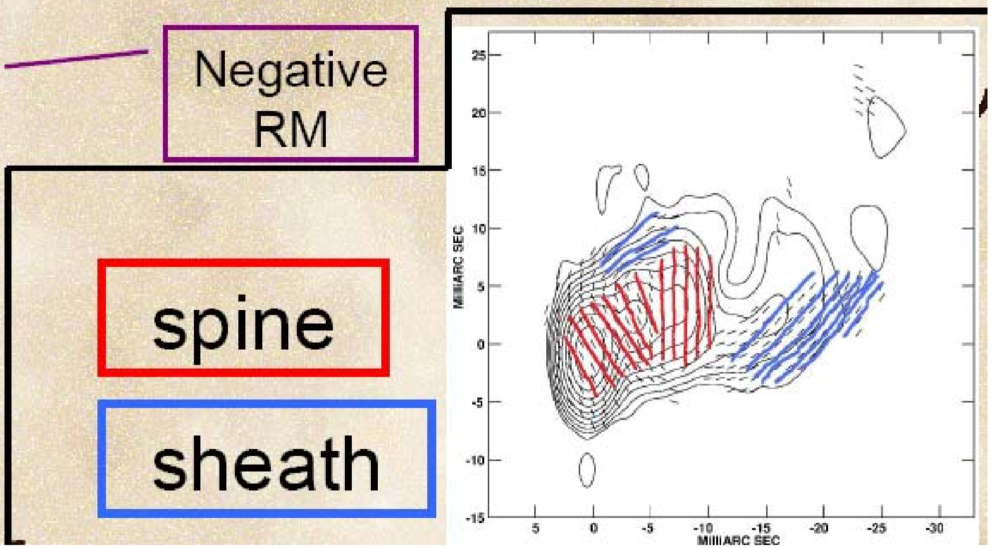
Linear polarization distribution, contours of p, ticks show the orientation of the magnetic field

Total intensity contours + ticks showing the orientation of the magnetic field

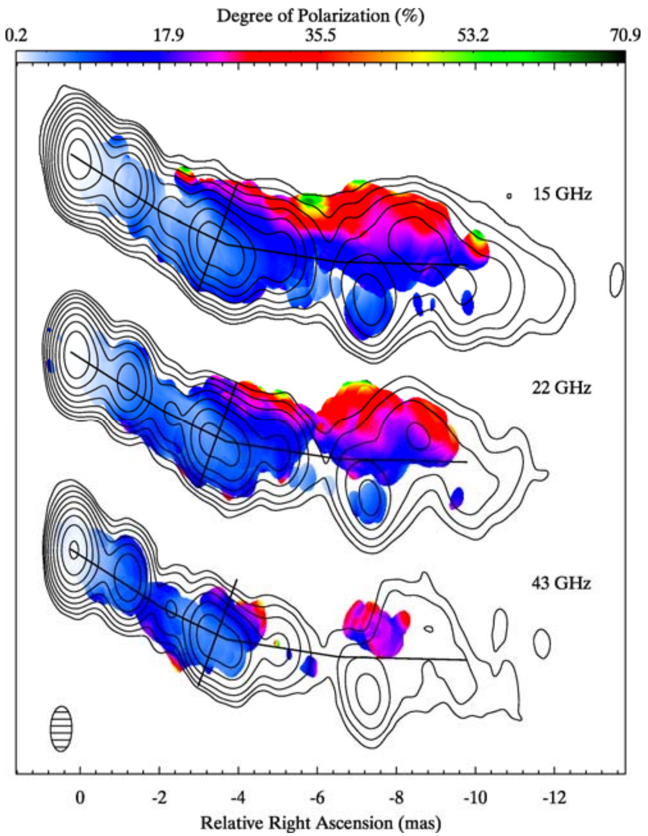
Helical B-Fields

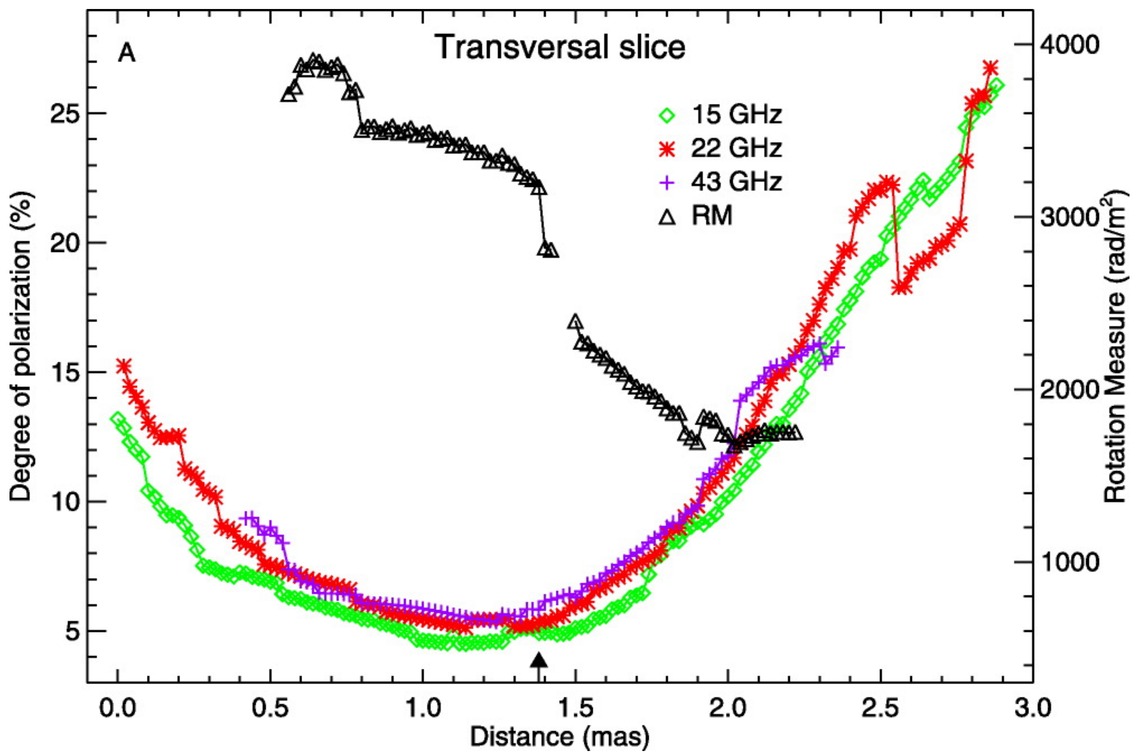


→ Systematic changes in the LOS B-field component accross the jet, with increasing values towards the jet-boundaries



The case of 3C 120



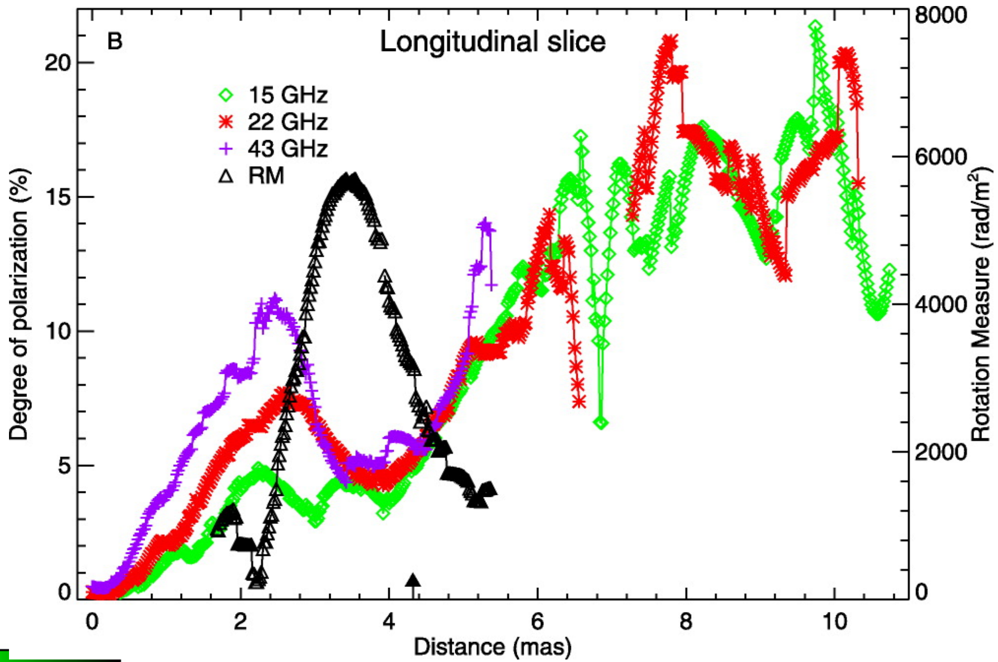


There is a systematic presence of gradients in RM (Faraday Rotation) and degree of polarization accross the jet: RM is larger at the southern side; the polzn degree increases towards the edges → Helical Jet

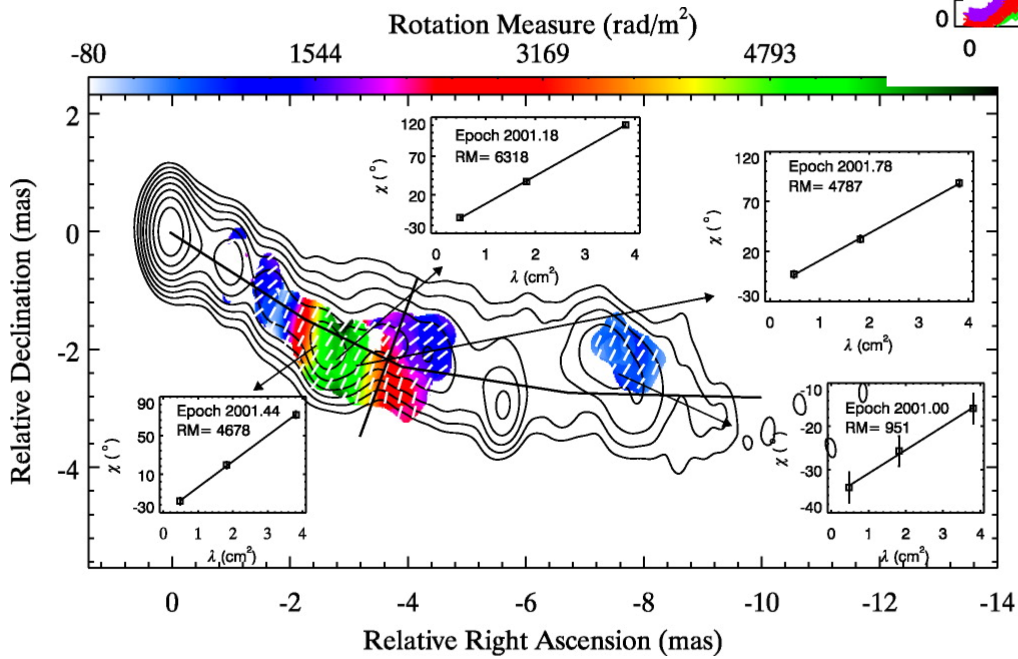
Gómez et al. ApJ 681, L79 (2008)

The case of 3C 120

The polzn degree increases
with distance from the core →



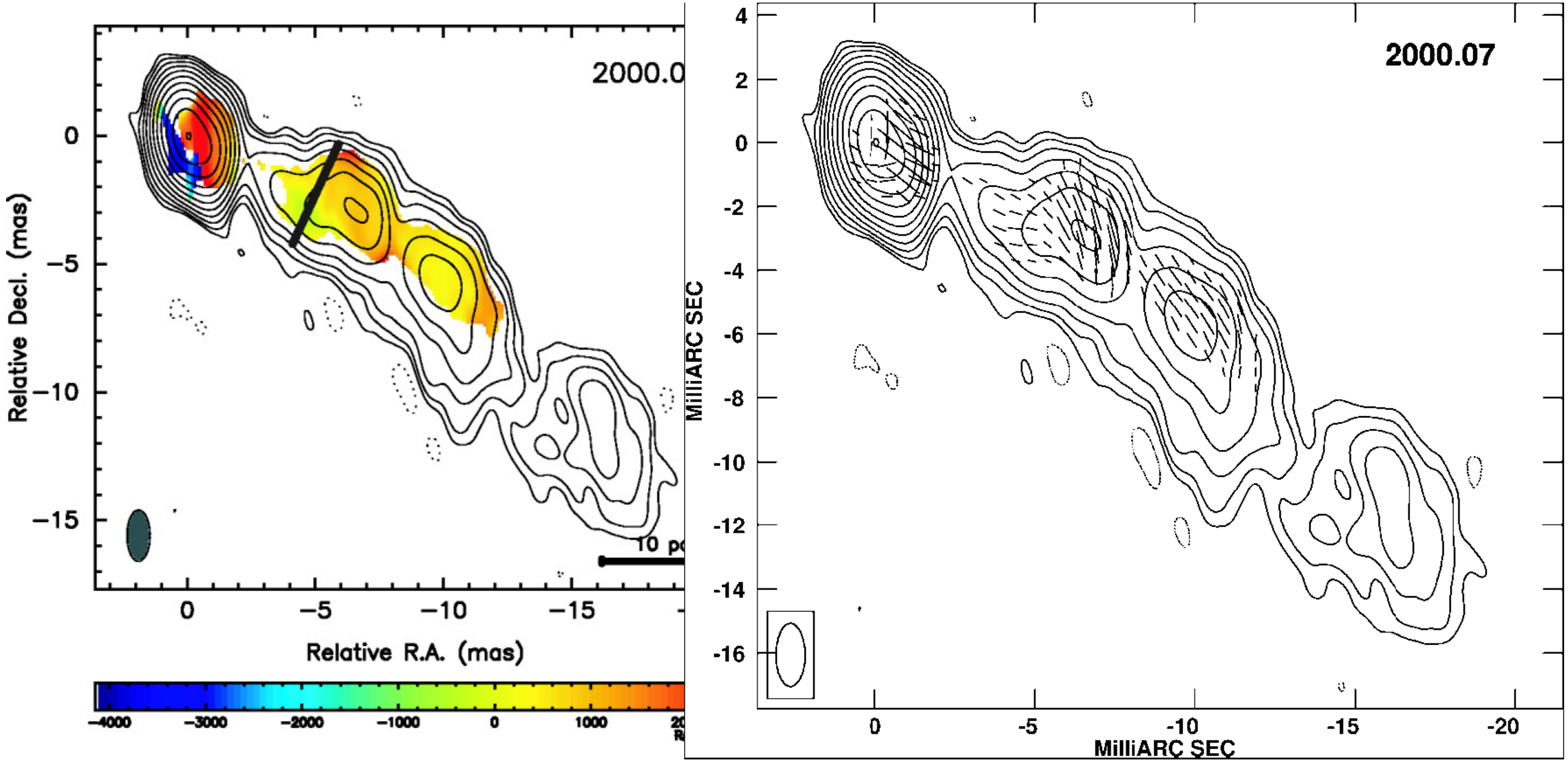
Interaction of the jet
with a cloud at 2-3 mas.
Dominant poloidal B-field
↓



The data are consistent with a helical field in a two fluid jet model (an external RM screen is suggested), consisting of an inner emitting jet and a sheath containing non-relativisitic electrons

Gómez et al. ApJ 681, L79 (2008)

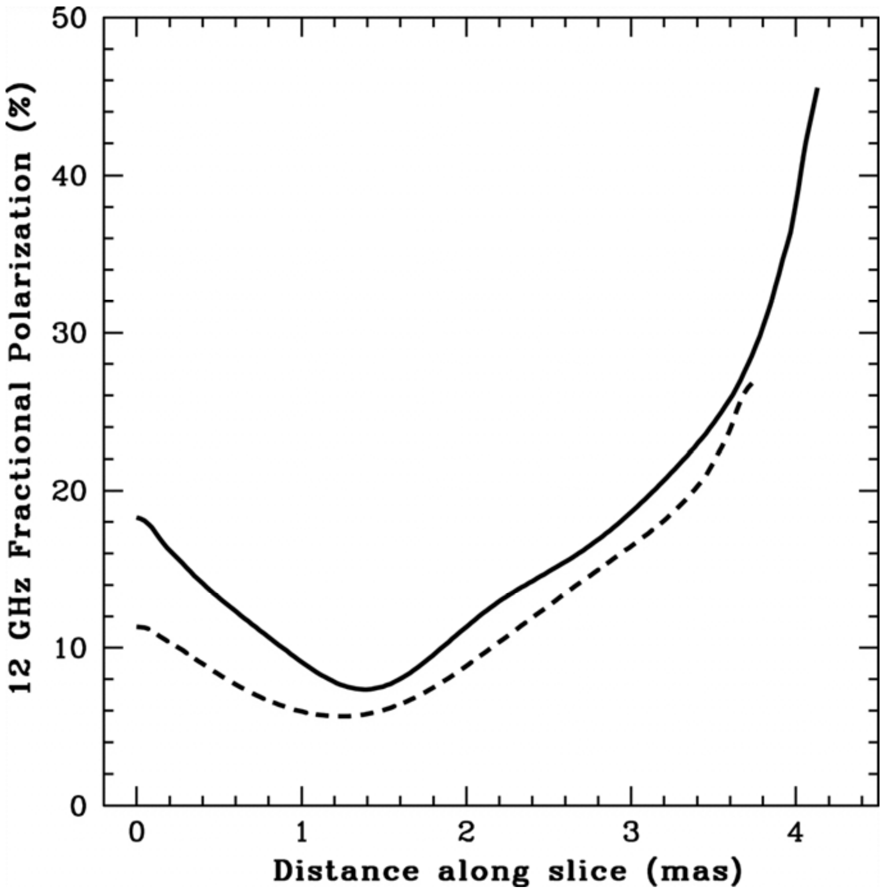
The case of 3C 273

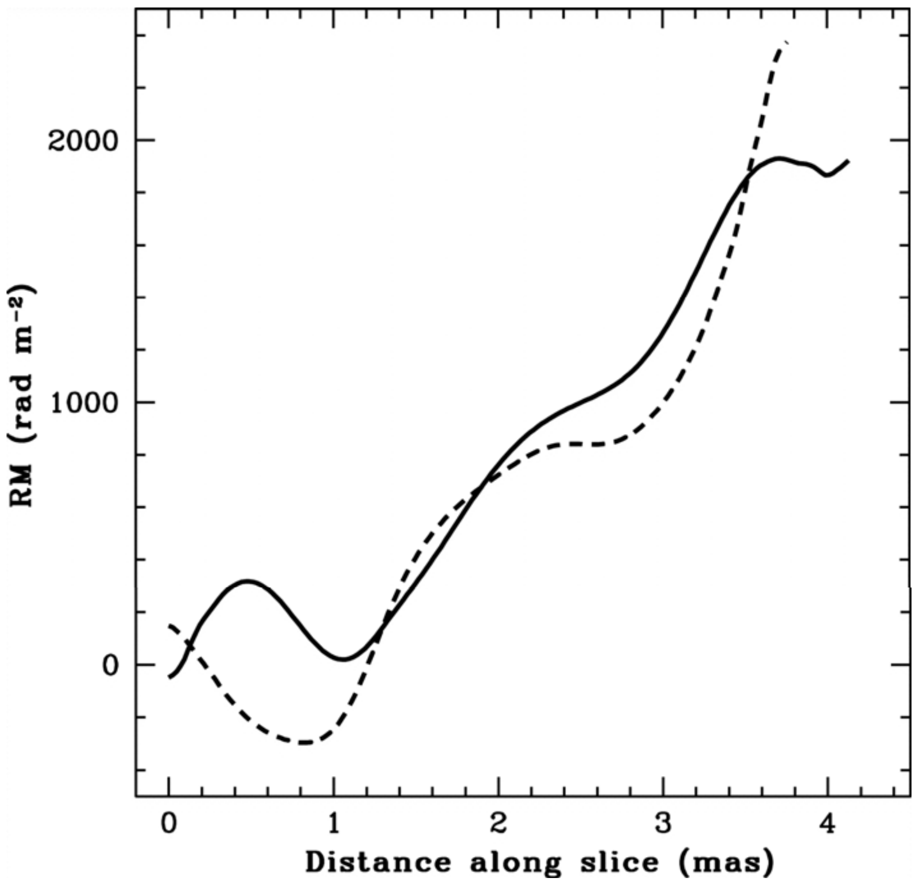


There is a stable Faraday Rotation Measure Gradient of 500 rad/m^2·mas transverse to the jet axis → a helical magnetic field wraps around the jet

Zavala et al. ApJ 626, L73 (2005)

The case of 3C 273

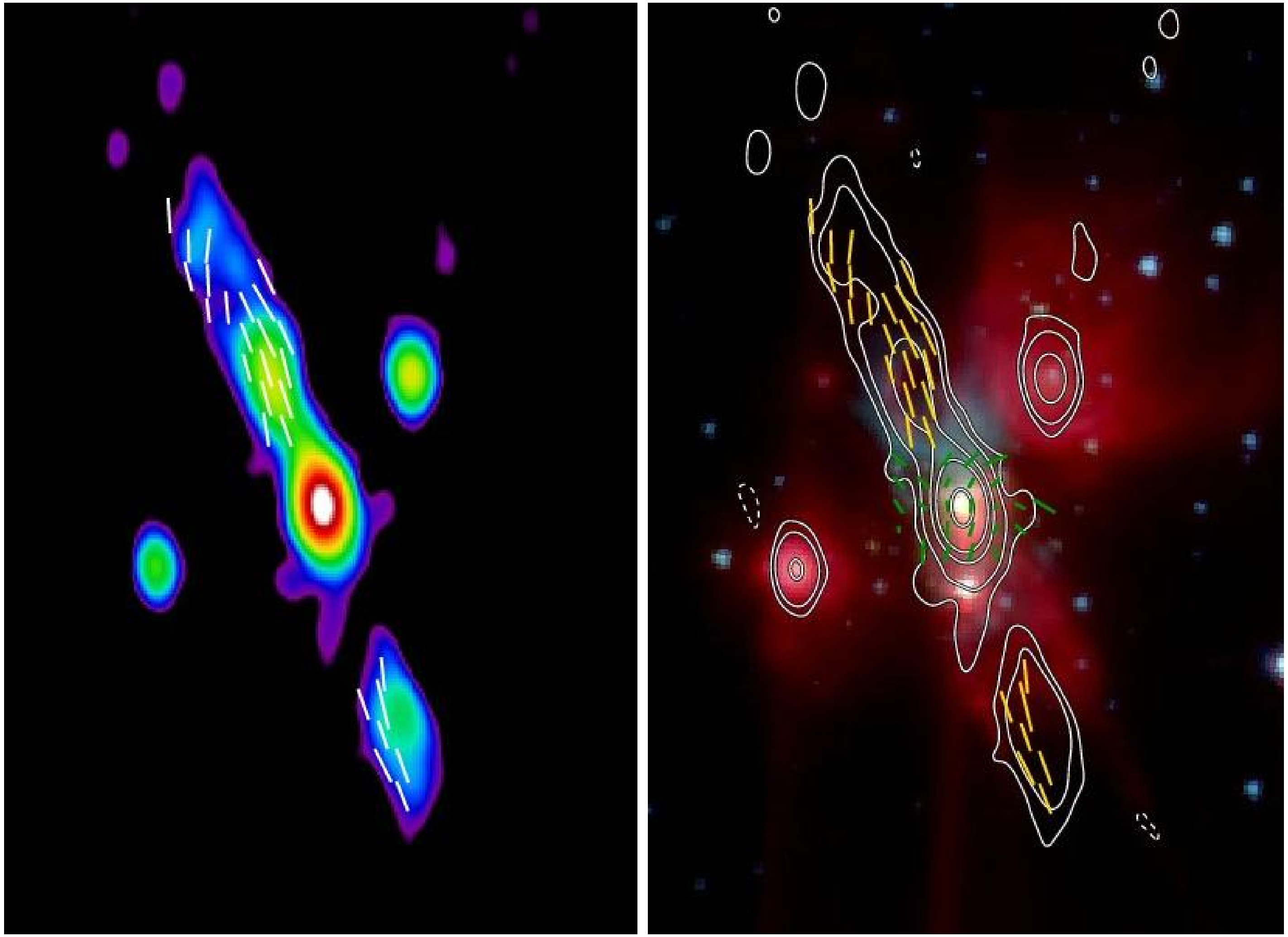




It is also found that the degree of polarization increases towards the center → Internal Faraday Rotation is ruled out. It is consistent with a shear layer produced by the interaction of the jet with external medium

Zavala et al. ApJ 626, L73 (2005)

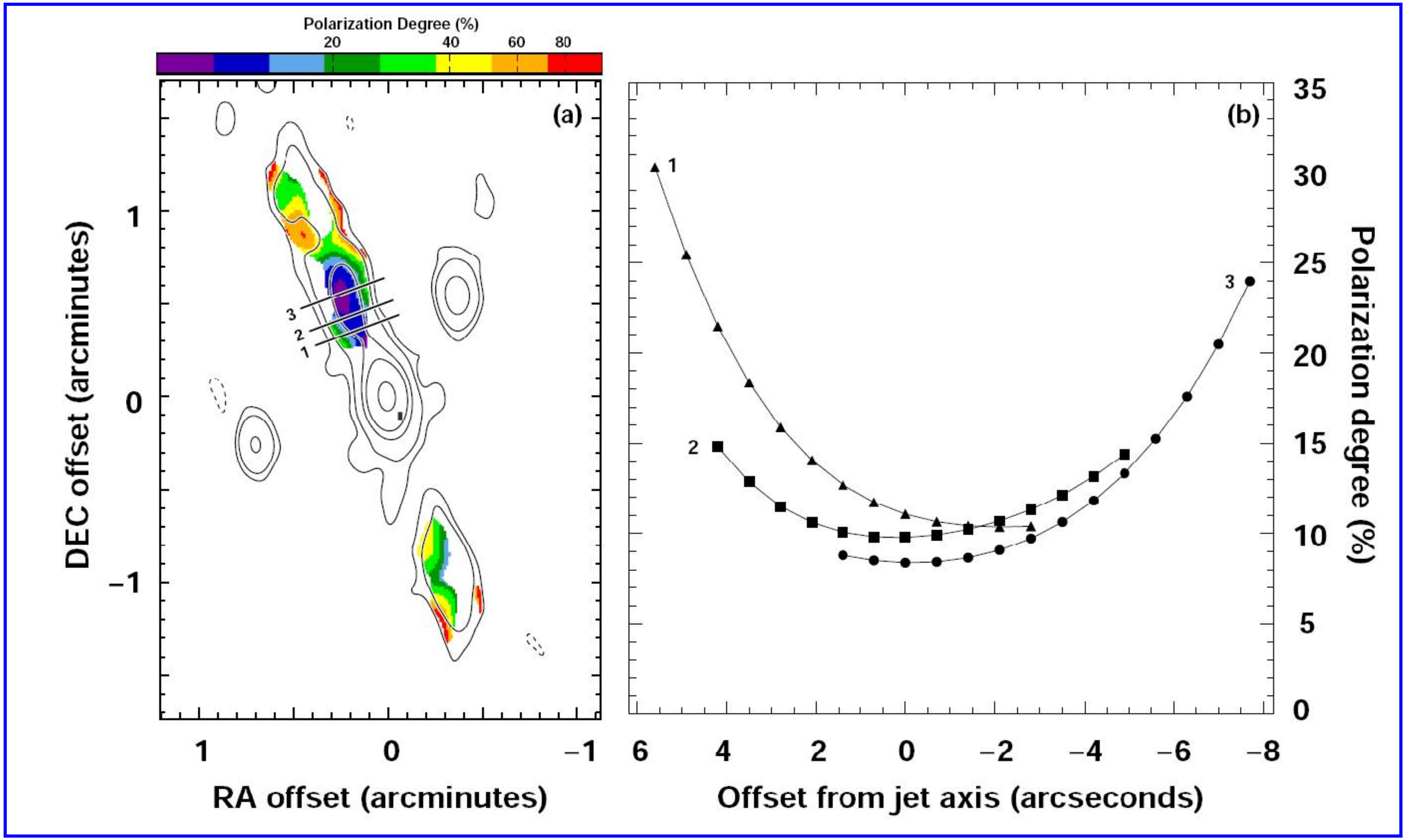
Magnetic Field in HH80-81



Detection of Polarization in a YSO: a magnetic field (~0.2 mG) at a distance of ~100.000 AU, parallel to the jet axis

Carrasco et al. Science (2010), in press

Magnetic Field in HH80-81



The polarization degree increases towards the jet edges, as expected for a confining magnetic field

Carrasco et al. Science (2010), in press