The Polarized Radio Emission of the Microquasar SS 433
&
3-D Faraday Rotation Imaging

Outlook & Progress

Michael Bell

Torsten Enßlin, Thomas Riller

Max Planck Institute for Astrophysics
Outline

- 'Previous' work
  - The microquasar SS 433
  - VLA Imaging
  - Interpreting the polarized emission
- Current project: 3-D RM imaging
  - Signal reconstruction algorithms
  - Practice w/ 2+1D implementation
  - Generation of test data – Hammurabi
  - Reconstruction of test data
- What's next?
Previous Work

Brandeis University
John Wardle – Dave Roberts

W50

SS 433

Dubner, et. al., 1998

Blundell & Bowler, 2004
**Observations**

- Five VLA A-array observations
- 5 & 8.5 GHz
- Particularly interested in polarized flux
  - Highly polarized
  - Complex EVPA structure
  - Very highly polarized emission in off-jet region
Changing EVPA behavior
Rotation Measure

June 8th
What is going on?

- We propose:
  - Jet tube is stretched as material flows outward
  - Jet breaks up due to instability
  - Individual ‘blobs’ elongate
In my free time...

- Still active on this
  - Toy Magnetic field model
  - Publish some results

- Just proposed follow-up eVLA observations
  - C band: Confirm RM structure, observe EVPA transition
  - K band: Observe inner 1” in detail, model will be highly testable
3D RM Synthesis

• RM synthesis and synthesis imaging in one step

\[ P(u, v, \lambda^2) \propto \int \int \int F(l, m, \phi) e^{2\pi i (\phi \frac{\lambda^2}{\pi} - ul - vm)} \]

• But first... practice in 2+1D
  • Implement and test algorithms
  • Simulated data set: HAMMURABI
Testing

- Hammurabi (Waelkens et al., 2008)
  - Simulation of galactic synchrotron emission
  - User defined model of B field, CRE, $n_e$
- My modifications...
  - Compute dispersion function as we integrate along the L.O.S.
  - Fourier transform gives $P(\lambda^2)$
- Proof of concept with realistic signal
  - Test different reconstruction techniques
  - Later apply to real data: GMIMS survey
Galactic Dispersion Function

Dispersion Function - Lat: $\pi/4$ - Long: $\pi/4$

HealCube - Polarized Intensity - 0 rad/m/m

HealCube - Polarized Intensity - 30 rad/m/m

HealCube - Polarized Intensity - -30 rad/m/m
Simulated Maps

- Very low resolution
  (for now...)
  50 sq. deg. per pix
- FFT of dispersion function
- Examples
  
  Top: 1.5 GHz
  Bottom: 500 MHz
Signal Covariance Matrix

The Wiener Filter

\[ d = R_s + n \]

P(\lambda^2) \quad FFT

The Wiener Filter

\[ F(\phi) \]

Gaussian signal prior
w/covariance matrix S

Gaussian noise prior
w/covariance matrix N

WF = \( (S^{-1} + R^\dagger N^{-1}R)^{-1} R^\dagger N^{-1} \)
Reconstruction

Dispersion Function - Lat: 45° - Long: 45°

Signal

'Dirty Image'

RMCLEAN

Wiener Filter
Reconstruction, cont.

Signal

'Dirty Image'

RMCLEAN

Wiener Filter
Reconstruction, cont.

Dispersion Function - Lat: 0° - Long: 150°

- Signal
- 'Dirty Image'
- RMCLEAN
- Wiener Filter
Reconstruction, cont.

Dispersion Function - Lat: 0° - Long: 110°

- Signal
- 'Dirty Image'
- RMCLEAN
- Wiener Filter
Now what...

• Continue to test algorithms
  – Compute S from data (iteratively)
  – How does each perform in specific situations?

• Working with Thomas Riller on LOFAR RM pipeline

• Very soon: Begin development of 3D Imaging software

THANKS!