Search for Extreme Rotation Measures in CSS Sources
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Motivation

- High plasma densities and strong magnetic fields are expected near BH at core of AGN nuclei
- Magnetized plasma is birefringent, rotating the polarization angle of linear polarization.
- Faraday rotation:

\[ \chi = \chi_0 + RM \cdot \lambda^2 \]

*Polarization angle, \( \chi \), rotates with wavelength squared
RM = Rotation measure*
Faraday Rotation

- Rotation measure is integral of electron density times component of magnetic field along LOS.

\[
RM = \frac{e^3}{8\pi^2\epsilon_0 m^2 c^3} \int n_e B_\parallel \, dl.
\]
Faraday rotation in AGN nuclei

- Background radiation will be Faraday rotated passing through dense magnetized plasma.
- Varying Faraday rotation can depolarize.
- Sgr A* strongly depolarized at cm wavelengths.
- Sgr A* has RM $\sim \frac{1}{2}$ million, could be more in more active nuclei.
Cartoon AGN nuclei
Detection of Dense Magnetized Plasma

- Polarimetric measurements can detect Faraday Rotation near nuclei of AGN.
- Multiple LOSs with different RM may depolarize, low fractional polarization may indicate dense screen.
- Need emission embedded in or behind screen.
CSS Nuclei

- Many are weakly polarized at cm $\lambda$
- Possibly depolarized by dense screen
- Better observed at short $\lambda$
  - Faraday effects are less
  - Opacity is less $\Rightarrow$ see closer to nucleus
- but CSS sources are faint at short $\lambda$.
- EVLA has good sensitivity 20 – 45 GHz
**EVLA Observation of CSS Sources**

- 3C48, 3C138, 3C147, (3C286) in standard calibrator observations (public).
- $6 \times 1$ GHz bands 20 – 45 GHz
- A configuration, $\sim$60 mas resolution
- Image at common resolution
- Pixel by pixel fitting of RM
- Examine nucleus
Pol contours, Fpol color, EVPA vectors
3C138

I Pol contours, Fpol color, EVPA vectors
3C138 with ALMA band 6 240 GHz

I Pol contours, Fpol color, EVPA vectors
3C147

I Pol contours, Fpol color, EVPA vectors
Results

- 3C48 fpol low but increases with frequency, RM $\sim$ 10,000
- 3C138, low fpol, core RM $\sim$-3000
  - < cm value (Cotton+ 2003 RM $\sim$-5000)
  - seen through holes in apparently dense Faraday screen.
  - ALMA result supports
- 3C147, low RM, high Fpol
- High RM components possibly masked by low RM components, need denser $\lambda^2$ coverage.
- Need higher frequencies to get closer to the BH
Faraday Analysis

- Multiple RM/complex structures can be revealed by Faraday Analysis
- Fourier Transforms data in $\lambda^2$ space.
- Separate RM components seen as peaks.
- Need dense coverage to get good transfer function.
- Allows detection of high RM component in the presence of low RM.
Further observations

- EVLA measure nearly complete 20-48 GHz on a selection of sources – in progress.
- ALMA Cycle 3 proposal for several sources at 350 GHz.
Summary

- Low fpol, moderate RM seem in 3C48, 3C138 up to 45 GHz
- 3C147, high fpol, low RM
- Continuing observations to do Faraday analysis
- Higher frequencies?