LINEARLY POLARIZED PROPERTIES AND ROTATION MEASURE STUDY OF PARSEC-SCALE AGN JETS

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KEY ASPECTS OF THE STUDY

GOAL:

STUDYING MAGNETIC FIELD STRUCTURE OF THE AGN JETS

BY ANALYSING:

FRACTIONAL POLARIZATION:
  RE/DEPOLARIZATION EFFECTS
FARADAY ROTATION
  TRANSVERSE RM GRADIENTS
INTRINSIC ELECTRIC FIELD STRUCTURE
SAMPLE & OBSERVATIONAL SETUP

20 SOURCES:

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9 VLBA FREQUENCIES: 1.41, 1.66, 2.28, 2.39, 4.60, 5.00, 8.11, 8.43 (16 MHZ BANDWIDTH) & 15.4 (32 MHZ BANDWIDTH) GHZ

SINGLE EPOCH VLBI PARSEC-SCALE OBSERVATIONS IN 2007

SOURCES WITH HIGH CORE SHIFTS (SEE SOKOLOVSKY ET AL. 2011)

SEPARATE ANALYSIS FOR THE MODELLED OPAQUE CORE AND TRANSPARENT JET COMPONENTS, VISIBLE ACROSS 9 OBSERVABLE FREQUENCIES

SIMILAR KPC STUDIES:
FARNES+ 2014
PASETTO+ 2015
ANDERSON+ 2016
FRACTIONAL POLARIZATION

RESULTS: STATISTICS

DISTRIBUTION ACROSS 9 FREQUENCIES IN 20 SOURCES
FRACTIONAL POLARIZATION & EVPA

EXTERNAL ROTATION: **TRANSPARENT JET COMPONENTS**

MAJORITY TRANSPARENT JETS EXHIBITS ROTATION ON EXTERNAL FARADAY SCREENS, WHILE FEW SOURCES SHOW INTERNAL ROTATION

EXTERNAL ROTATION - RANDOM (TURBULENT) OR REGULAR MAGNETIC FIELDS IN INHOMOGENOUS INOZED MEDIUM

THIS DATA AND FIGURES ARE MADE FOR MODELLED OPTICALLY THIN JET COMPONENTS (PIXEL VALUES)
FRACTIONAL POLARIZATION & EVPA

INTERNAL ROTATION: **TRANSPARENT JET COMPONENTS**

Majority transparent jets exhibit rotation on external Faraday screens, while few sources show internal rotation.

**EXTERNAL ROTATION** - random (turbulent) or regular magnetic fields in inhomogenous inozed medium.

**INTERNAL ROTATION** — helical or twisted magnetic fields.

This data and figures are made for modelled optically thin jet components (pixel values).
FRACTIONAL POLARIZATION & EVPA

OPAQUE JET COMPONENTS

OPAQUE CORES HAVE MORE COMPLEX POLARIZED STRUCTURE, APPLYING THAT POLARIZED FLUX GOES FROM DIFFERENT REGIONS WITHIN A SOURCE

PHYSICAL INTERPRETATION:
HELICAL/TWISTED MAGNETIC FIELDS
MULTIPLE ROTATION MEASURE OR JET COMPONENTS SMEARED WITHIN A BEAM
DEPOLARIZATION ON EXTERNAL FARADAY SCREEN

THIS DATA AND FIGURES ARE MADE FOR MODELLED OPTICALLY THICK JET COMPONENTS (PIXEL VALUES)
EVPA IN THE CORES

RM INCREASE TOWARDS SHORTER WAVELENGTHS: CORE SHIFTS

THIS DATA AND FIGURES ARE MADE FOR MODELLED OPTICALLY THICK JET COMPONENTS (PIXEL VALUES)

EVPAs ARE CORRECTED FOR GALACTIC RM
FARADAY ROTATION MEASURES

\[ \text{RM} \sim \int n_e B \parallel dl \]

CONSTRUCTED 43 ROTATION MEASURE MAPS

- 1.4 – 2.4 GHz
- 2.4 – 5.0 GHz
- 4.6 – 15.4 GHz

ROTATION MEASURE VALUES ARE VARIABLE AT MONTHs — YEARs SCALES, AS SEEN FROM COMPARISON OF OUR VALUES WITH MEASURES MADE BY OTHER AUTHORS

OBSERVABLE ROTATION MEASURE, CORRECTED FOR GALACTIC CONTRIBUTION

1049+215 Core

- FgRM = 9
- \( \text{RM}_{C1} = -4 \pm 4 \)
- \( \text{RM}_{C2} = -107 \pm 17 \)
- \( \text{RM}_{C3} = -547 \pm 52 \)
TRANSVERSE ROTATION MEASURE GRADIENT

2201+315

HELICAL FIELDS PRODUCE ROTATION MEASURE GRADIENTS TRANSVERSE TO JET

8 OUT OF 20 SOURCES SHOW SIGNIFICANT ROTATION MEASURE GRADIENTS

3 OUT OF THESE 8 MIGHT BE PRODUCED BY $N_E$ and/or $B_\parallel$ CHANGE RATHER THAN CHANGE IN ORIENTATION OF $B$
ELECTRIC FIELD STRUCTURE
CORRECTED FOR FARADAY RM: 0148+274

EVPA & LINEAR POLARIZATION

0148+274
EVPA vs. JET DIRECTION
CORRECTED FOR FARADAY RM

55% OF THE SOURCES HAVE EITHER PARALLEL OR PERPENDICULAR EVPAs RELATIVE TO JET DIRECTION

45% OF THE SOURCES INCLINE THEIR EVPAs AT ANGLES >20° & <70°

![Histogram showing EVPAs vs. Jet Direction](chart.png)
JET EVPAs ARE ROTATED BY 90 DEGREES (TO ALIGN CORE AND JET EVPAs, CHANGE IN OPACITY)

SMALL TENDENCY TO ALIGN EVPAs WITH THE JET DIRECTION

ALIGNMENT DOES NOT IMPLY EXISTENCE OF POLOIDAL MAGNETIC FIELD IN THE JET

SUCH DISTRIBUTION HAS BEEN OBSERVED BEFORE (E.G. POLLACK+2003, LISTER&HOMAN 2005, AGUDO+2014, )
ELECTRIC FIELD STRUCTURE
CORRECTED FOR FARADAY RM: 1458+718

SHEATH

FRACTIONAL POLARIZATION

SPINE+SHEATH

FRACTIONAL POLARIZATION + EVPAs

RM GRADIENTS
ELECTRIC FIELD STRUCTURE
CORRECTED FOR FARADAY RM: 1458+718

FRACTIONAL POLARIZATION

RM GRADIENTS

OBSERVED COMPLEX MAGNETIC FIELD GEOMETRY IS DUE TO SPINE-SHEATH JET STRUCTURE AND CHANGE IN LOS AT SOME POINT IN THE JET
SUMMARY

MAJORITY OF THE SOURCES ARE CONSISTENT WITH THE MODEL OF EXTERNAL FARADAY SCREEN, LOCATED CLOSE TO THE JET (MIGHT BE ITS OUTER LAYER, SHEATH, ETC.)

38 CASES (18 SOURCES). OBSERVED MAGNETIC FIELD STRUCTURE:

- POLOIDAL in the JET: ++++++++++
- RANDOM/REGULAR in the SCREEN: +++++++++++++++++
- HELICAL in the JET: ++++++
- HELICAL in the SCREEN: +++++++
- UNKNOWN in the JET/SCREEN: ++++

THERE IS NO SINGLE, ULTIMATE MODEL OF THE MAGNETIC FIELD STRUCTURE ABLE TO DESCRIBE ALL OBSERVED SOURCES.

SPINE (CENTRE) - SHEATH (SURROUNDING MEDIA) STRUCTURE, LOS AND RELATIVISTIC EFFECTS MAY DESCRIBE OBSERVED VARIETY OF POLARIZED CHARACTERISTICS. IN THIS CONTEXT, SHEATH HOLDS TURBULENT, REGULAR POLOIDAL OR TOROIDAL MAGNETIC FIELD. SPINE CONTAINS WEEL-ORDERED, LARGE-SCALE MAGNETIC FIELDS.

POOR SPATIAL RESOLUTION, INSTABILITIES, SHOCKS, JET BENDS, CHANGE IN JET GEOMETRY, JET ASYMMETRY, SOURCE FLARING ACTIVITY AFFECT INTRINSIC MAGNETIC FIELD ORIENTATION.