Scattering of AGN as a probe of small-scale structures in the interstellar medium with ATCA

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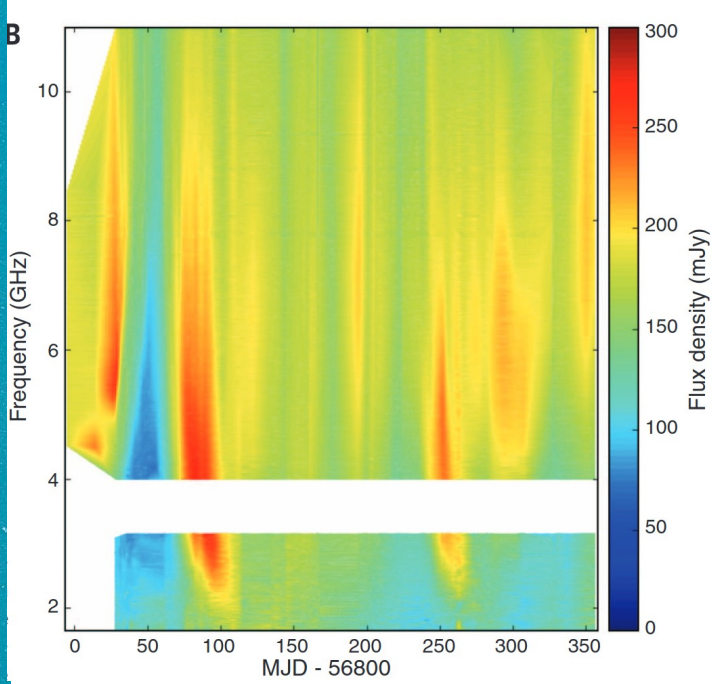
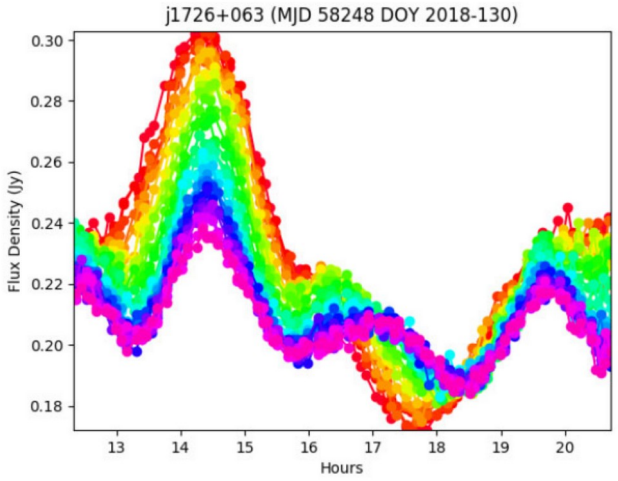


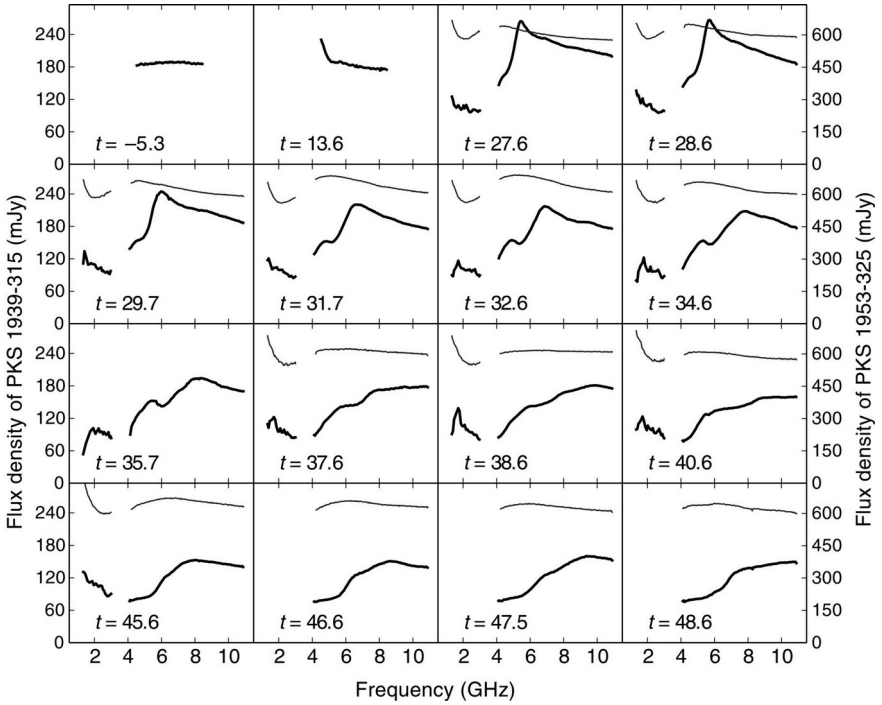


Outline

- Highlights from ATCA in the past decade:
  - Extreme Scattering Events
    - the ATESE Survey (Bannister++)
  - Intra-Day Variability and “annual cycles”
- What have we learned? What questions remain?
- Why ATCA?

The ATESE Survey

- Monthly snapshots of 1000 sources to find ESE spectral signatures
- Followed up candidates with daily monitoring



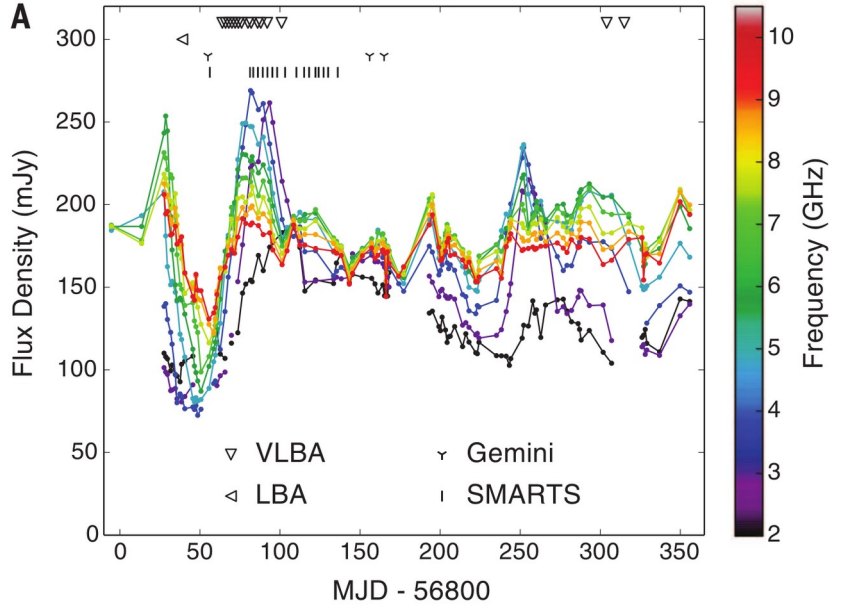
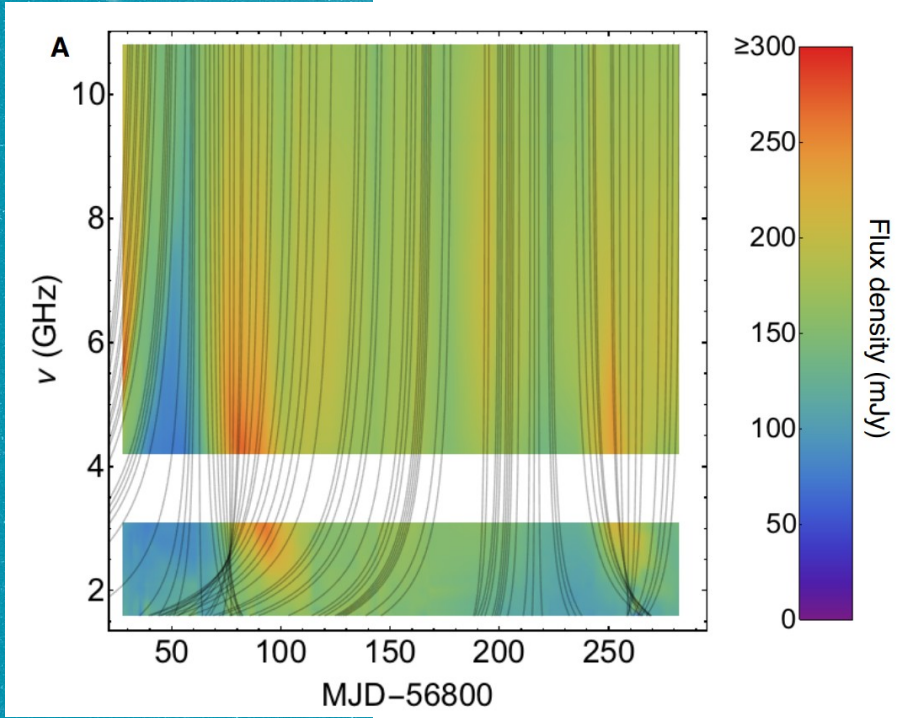


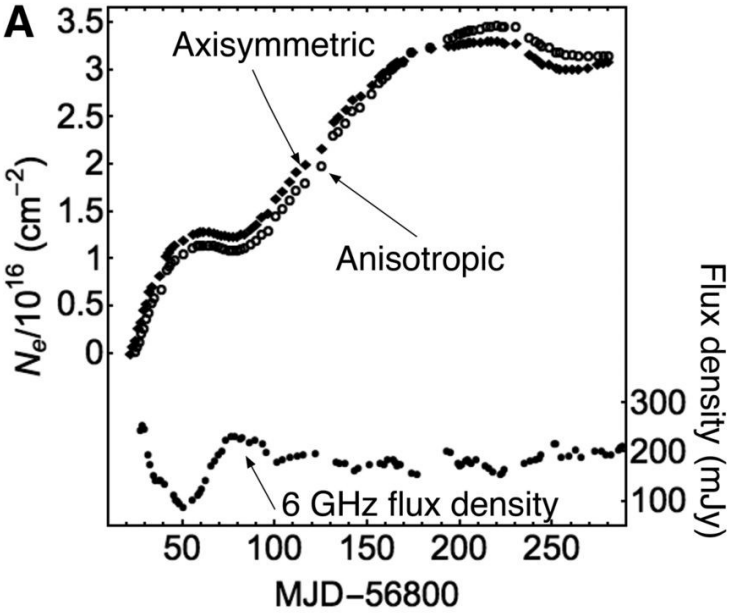
Fig. 2. One hundred four epochs of ATCA radio data of PKS 1939–315. (A)

Bannister+ 2016, *Science*, 351, p 354

Modelling ESEs

Dynamic Spectral Mapping of Interstellar Plasma Lenses
Tuntsov+ 2016, ApJ 817, 176





Modelling ESEs

Bannister+ 2016, Science 351, 354

One model ruled out by dynamic spectrum alone

Need other information to distinguish between models - VLBI can help

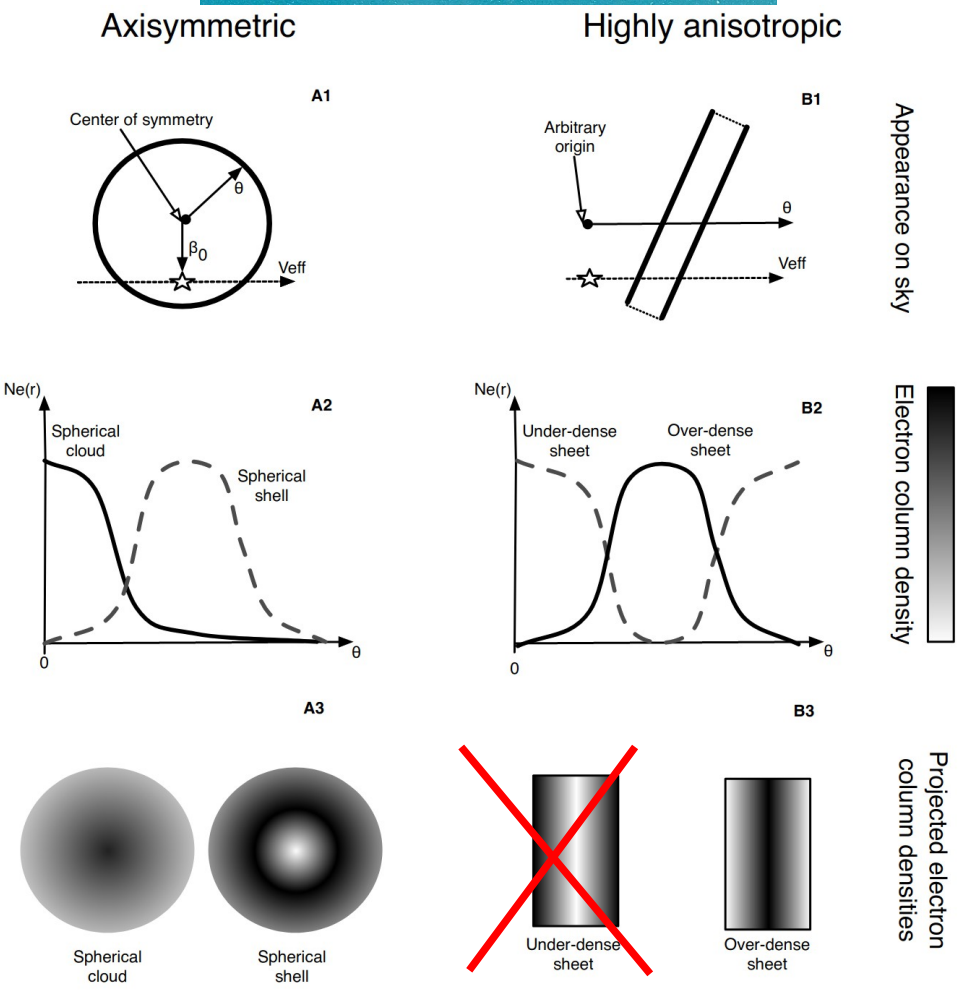
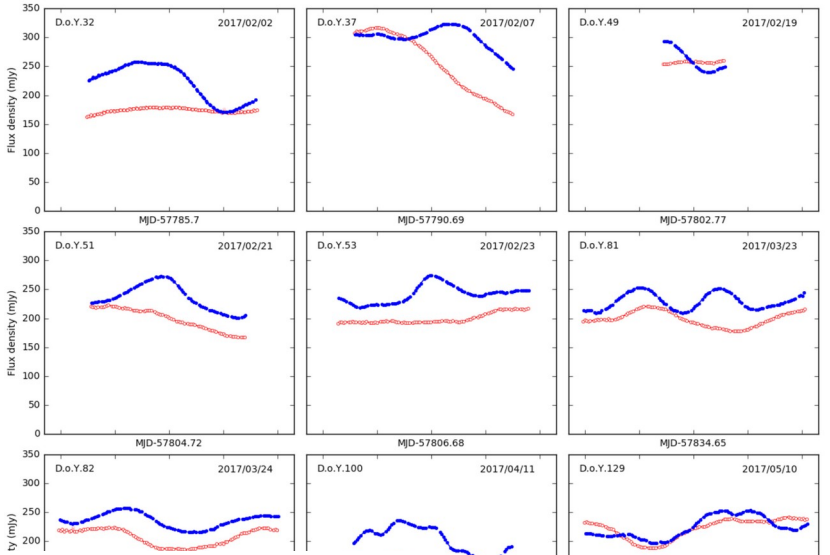


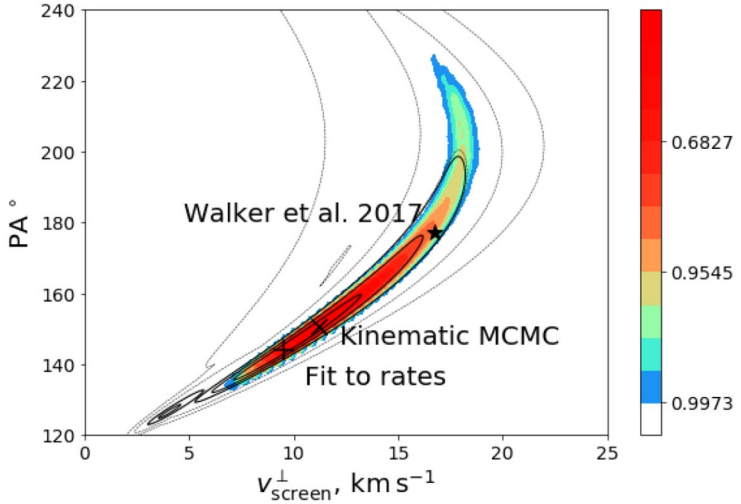
Fig S6.

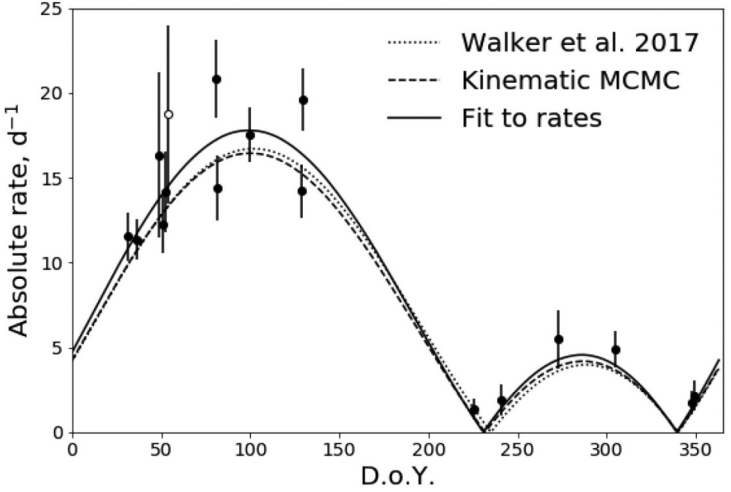
Cartoons of the two geometries considered in the lens modeling. The A panels depict

Interstellar scintillation

- **Spica and the annual cycle of PKS B1322–110 scintillations** (Bignall+ 2019, MNRAS 487, 4372)
- Supported the idea that interstellar scattering screens are (sometimes!) associated with hot stars



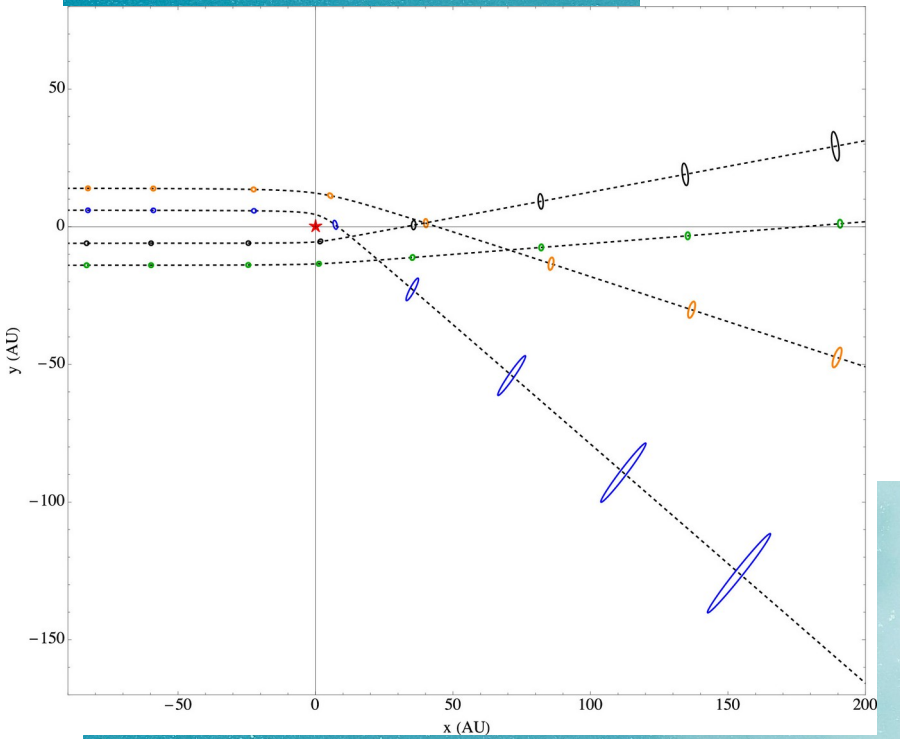




New theoretical work

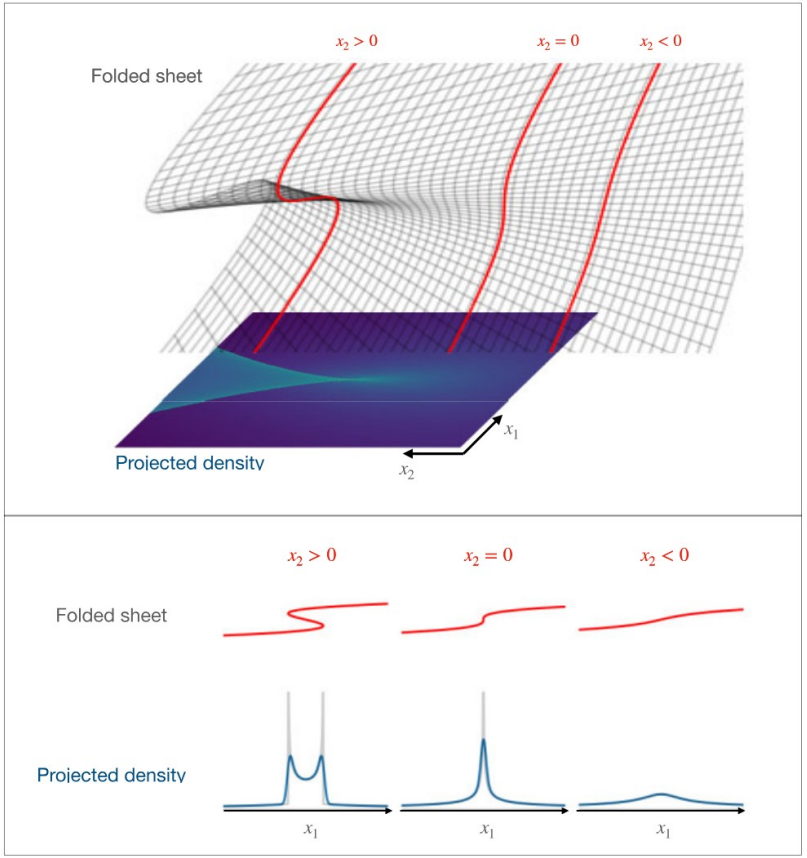
Suvorov and Walker (2025, ApJ 982, 61): Tidal Disruption of "Snow Clouds" by Unassociated Stars

“Snowballs in the shocked ISM leave tiny trails of ionized hydrogen that constitute plasma microstructure, and these microstructured regions are somewhat reminiscent of the "scattering screens" that cause scintillation in compact radio sources.”



New theoretical work

Jow+ (2024, MNRAS 528, 6292): “On the cusp of cusps: a universal model for extreme scattering events in the ISM”



Why ATCA?

The flexibility, frequency coverage and broad bandwidth available – especially with BIGCAT - make it ideal for studies of ESEs and interstellar scintillation.

Con: The instantaneous u,v coverage isn't great; source confusion can be an issue for accurate snapshot measurements. However:
Pro: the excellent calibration stability of ATCA makes a couple of approaches possible:

* LST-match observations and difference calibrated visibilities to look for changes on a timescale of a day (or N days)
* or combine snapshots from different hour angles/epochs to model the field.