Imaging Scintillation Arcs

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and collaborators

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- Pulsar B0834+06
Scintillation arcs

Dynamic spectrum
Scintillation arcs

Dynamic spectrum

Secondary spectrum

Fourier Transform

(Stinebring et al. 2001, Walker et al. 2005)
Scintillation geometry
Points represent stationary phase points of the Kirchoff-Fresnel integral. Only these “components” contribute significantly to the electric field at Earth.
Stationary phase points (2)

- Each stationary phase point has four properties: position, delay, delay rate, and intensity
- Models connect delay and rate to position
- Each pair of stationary phase points contributes to a single point in the secondary spectrum
Secondary spectrum shape

The secondary spectrum is the autocorrelation of the stationary phase point distribution.
Dynamic spectrum
(0.5% of spectrum is shown here)

Time (1 hour span @ 5 second resolution)

Frequency (300 kHz @ 250 Hz resolution)
Secondary spectrum (part 1)
Secondary spectrum (part 2)

1 ms delay
Stationary phase points (3)

- Decomposed by matching to template arcs
- Many artifacts remain
- Note emptiness of parabola: large anisotropy implied
VLBI observations

- 2 pulsar targets: B0834+06 and B1133+16
- 4 large radio telescopes: Westerbork, Jodrell Bank, Arecibo and Greenbank
- Baselines between 600 and 7900 km
- 310 – 342 MHz dual circular polarization
- 2.2 TB raw data recorded over 6 hours on Mark5
- Software correlated: 4x 32768 spectral channels
Visibility dynamic spectrum (AR — GB)
Visibility Secondary Spectrum (Amplitudes)

Delay range: 0 to 1.3 ms
Rate range: -100 to 100 mHz

$\log(I)$ – greyscale spans factor of 3600
Visibility Secondary Spectrum (Phases) I.

No Structure! (Well, not quite...)
Visibility Secondary Spectrum (Phases) II.

Symmetric portion of phases – purely geometric in origin

Linear greyscale:
black = -180, white = 180 deg.

Phases range from ~-40 to +40 deg.

Image scale is ~10 mas
Amplitude and Phase