

Interstellar scintillation :
turbulence under the microscope

Mark Walker
(Manly Astrophysics)

Physics of scintillation

Ionised gas



$$\delta\varphi \sim 1 \text{ for } N_e \sim 10^{11} \text{ cm}^{-2}$$

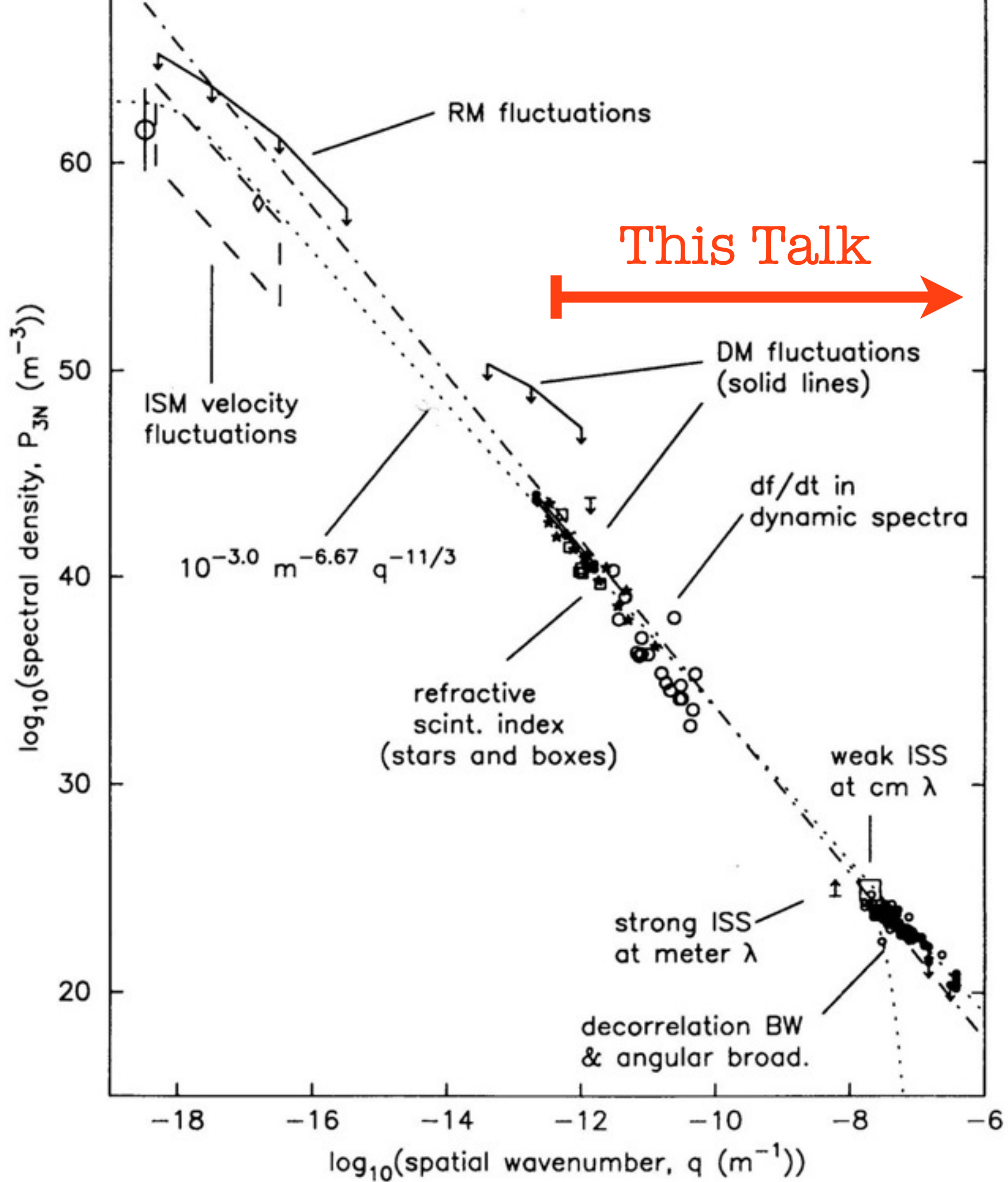
$$\text{Fresnel-scale} \sim 10^{11} \text{ cm}$$

$$\text{diffractive-scale} \sim 10^8 \text{ cm}$$

$$\text{refractive-scale} \sim 10^{14} \text{ cm}$$



Armstrong, Rickett & Spangler 1995



An Intra-Hour Variable Quasar



Properties of scattering structures

- $D \sim \text{few pc}$: For Intra-Hour Variable quasars
 - More distant for Intra-Day Variable quasars
 - Seen to kpc distances with pulsars ("Parabolic Arcs" : Stinebring et al)
- Size $\sim 10^{14 \pm 1} \text{ cm}$ (e.g. PKS 0405)
 - Episodic variability : MASIV (Lovell et al)
- $P_{\text{gas}} \sim 10^5 \text{ K cm}^{-3} \gg P_{\text{ISM}}$
- Number density $\sim 10^4 \text{ pc}^{-3}$
- Anisotropy of scattered images, $A \gg 1$

Image anisotropy

- $A \gtrsim 4$ from light-curves (Rickett et al 2002)

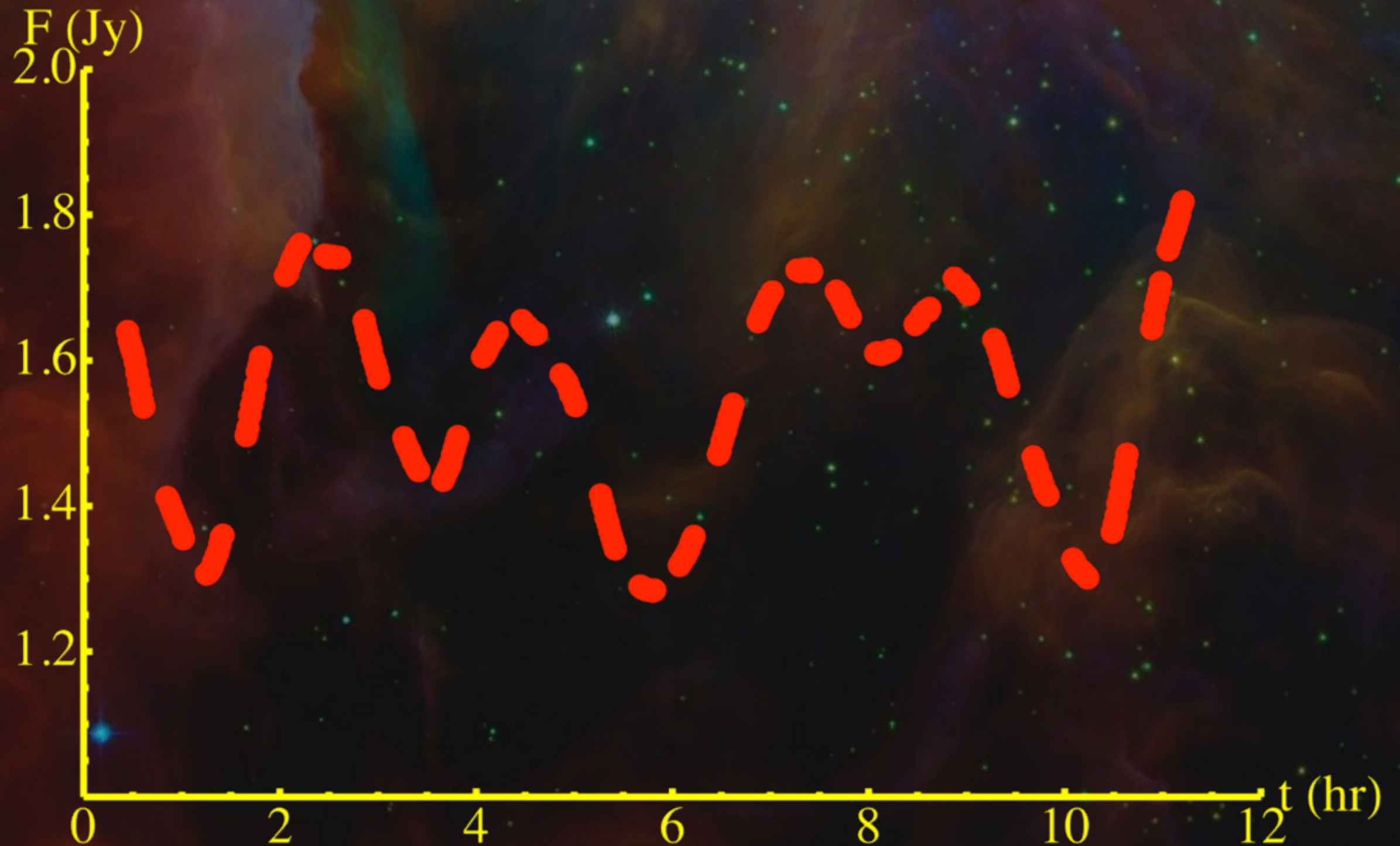


Image anisotropy

- $A \gtrsim 10$ from pulsar dynamic spectra
(Cordes et al 2006)

Image anisotropy

- $A \gtrsim 30$ from pulsar dynamic spectra (Briskin et al 2011)

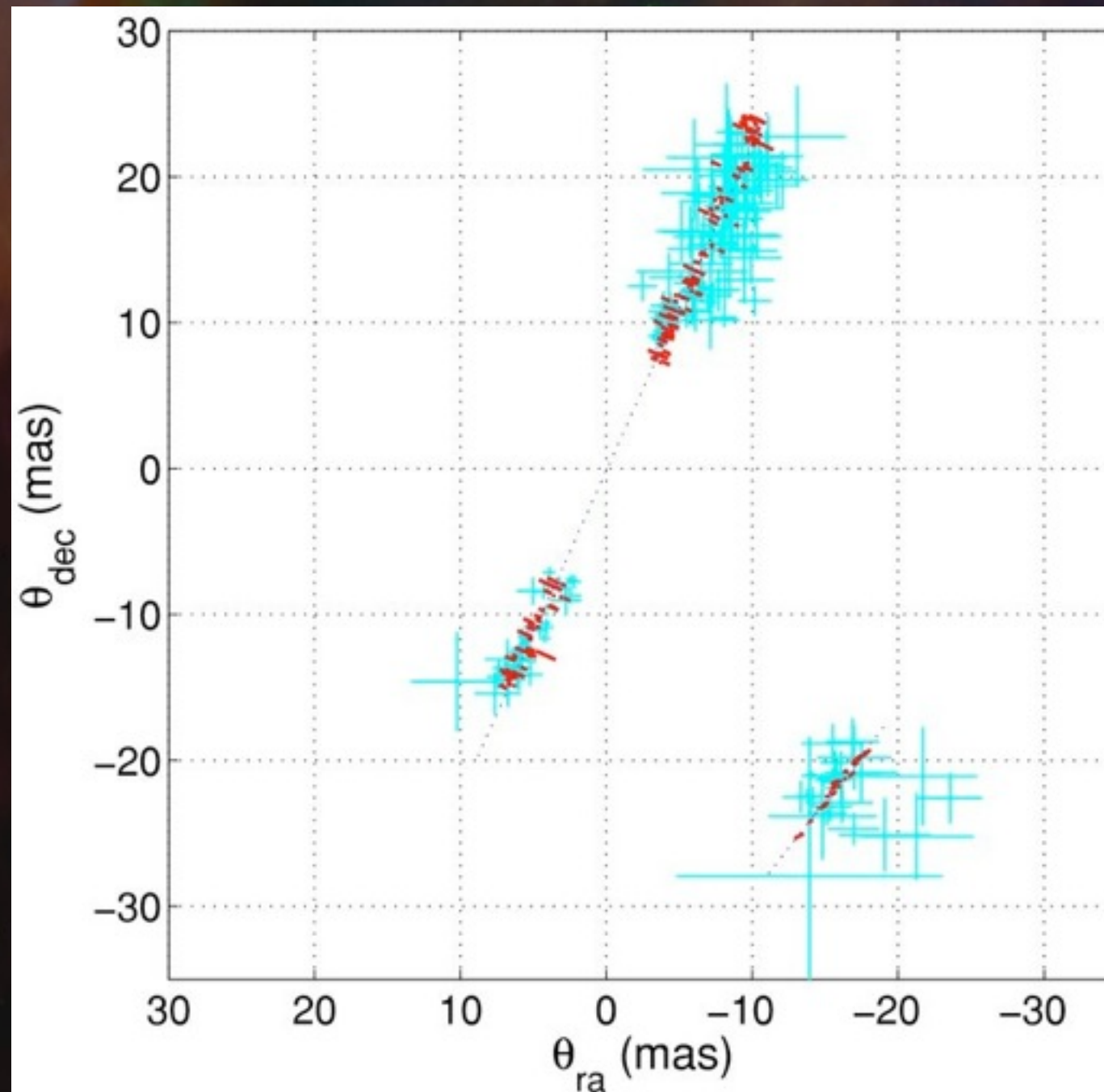


Image anisotropy

- $A \gtrsim 100$ from the kinematics of J1819+3845

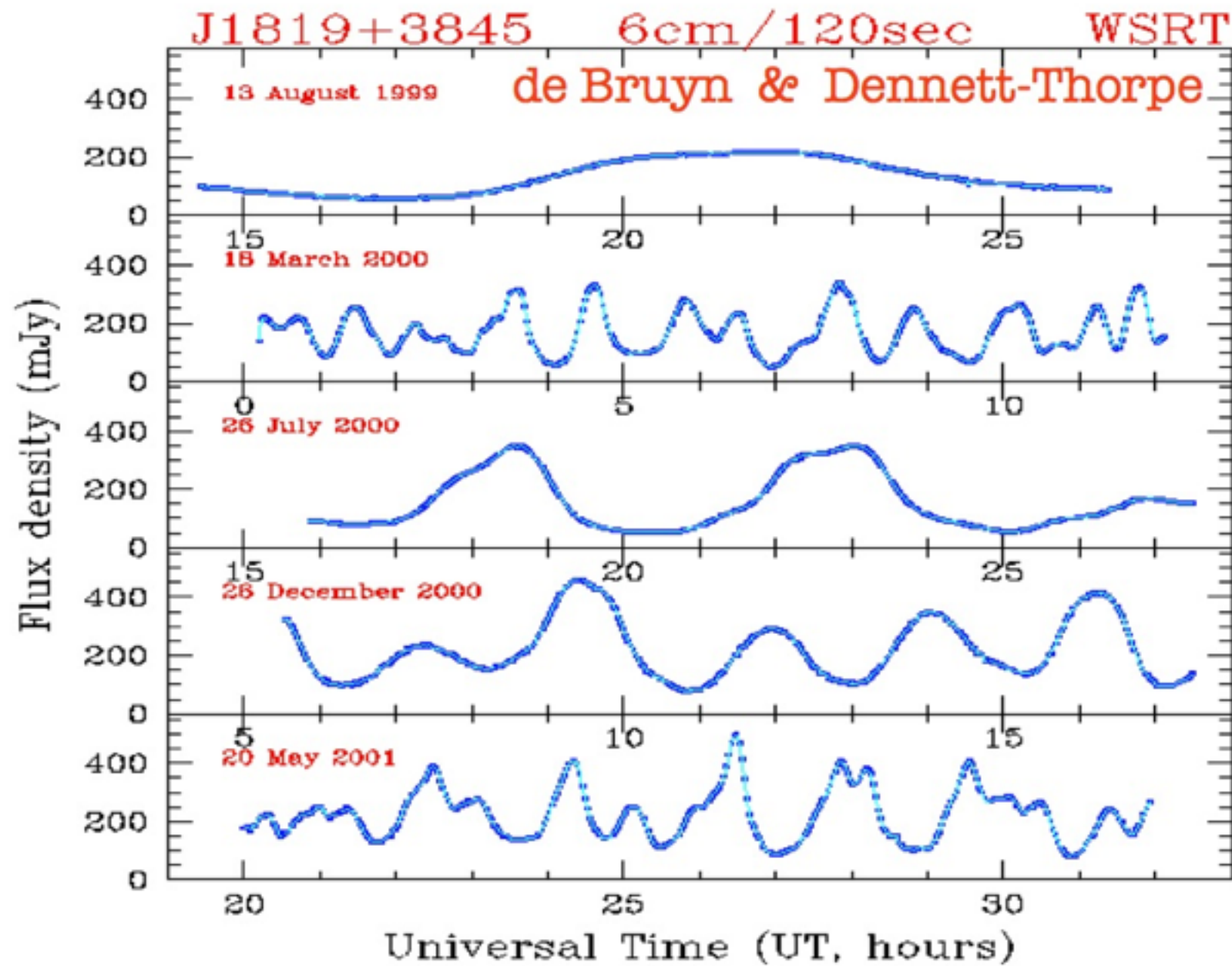
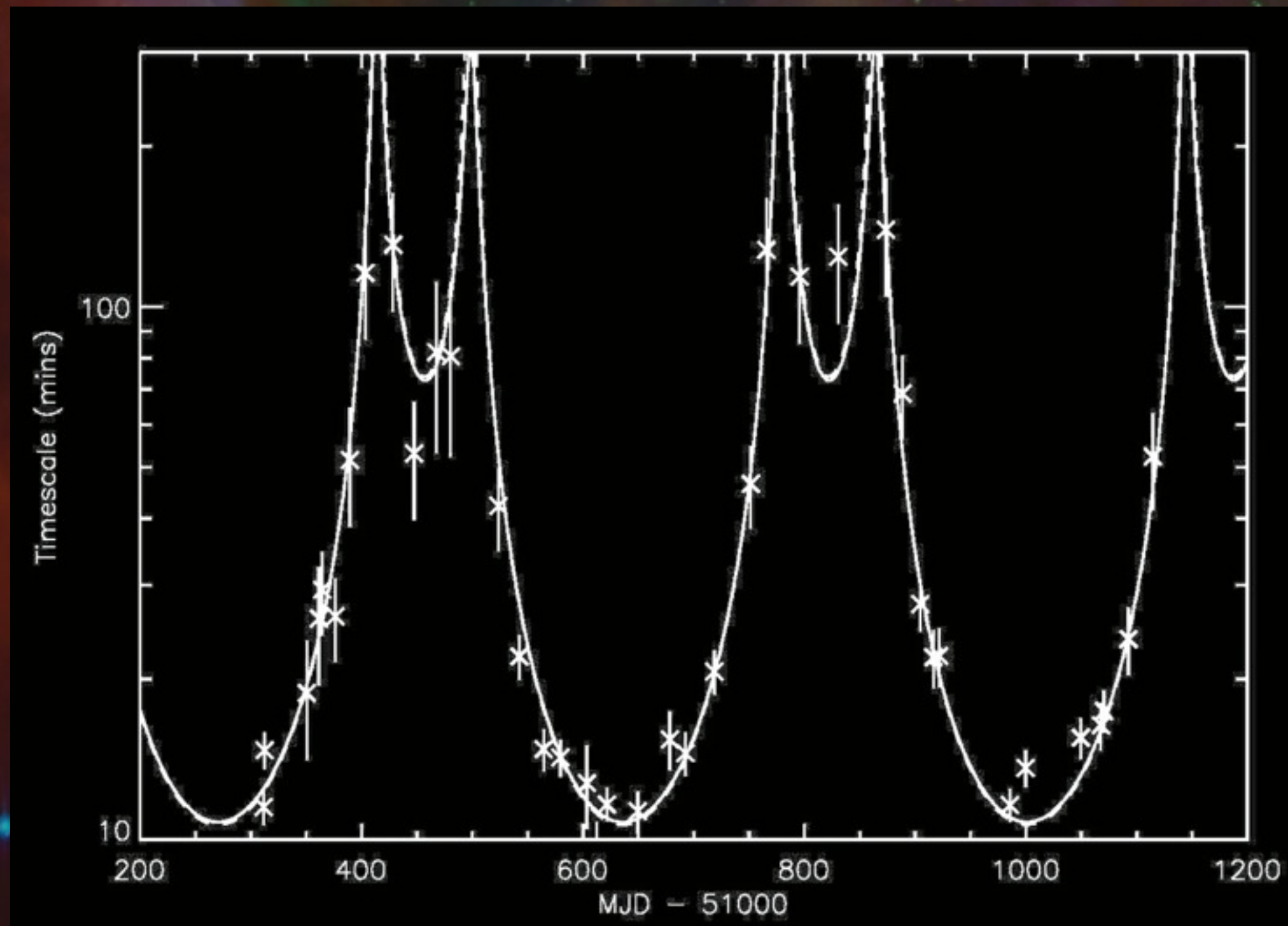


Image anisotropy

- $A \gtrsim 100$ from the kinematics of J1819+3845



Nature of scattering structures

$A \sim 10$

$A \sim 10$

$A \sim 100$

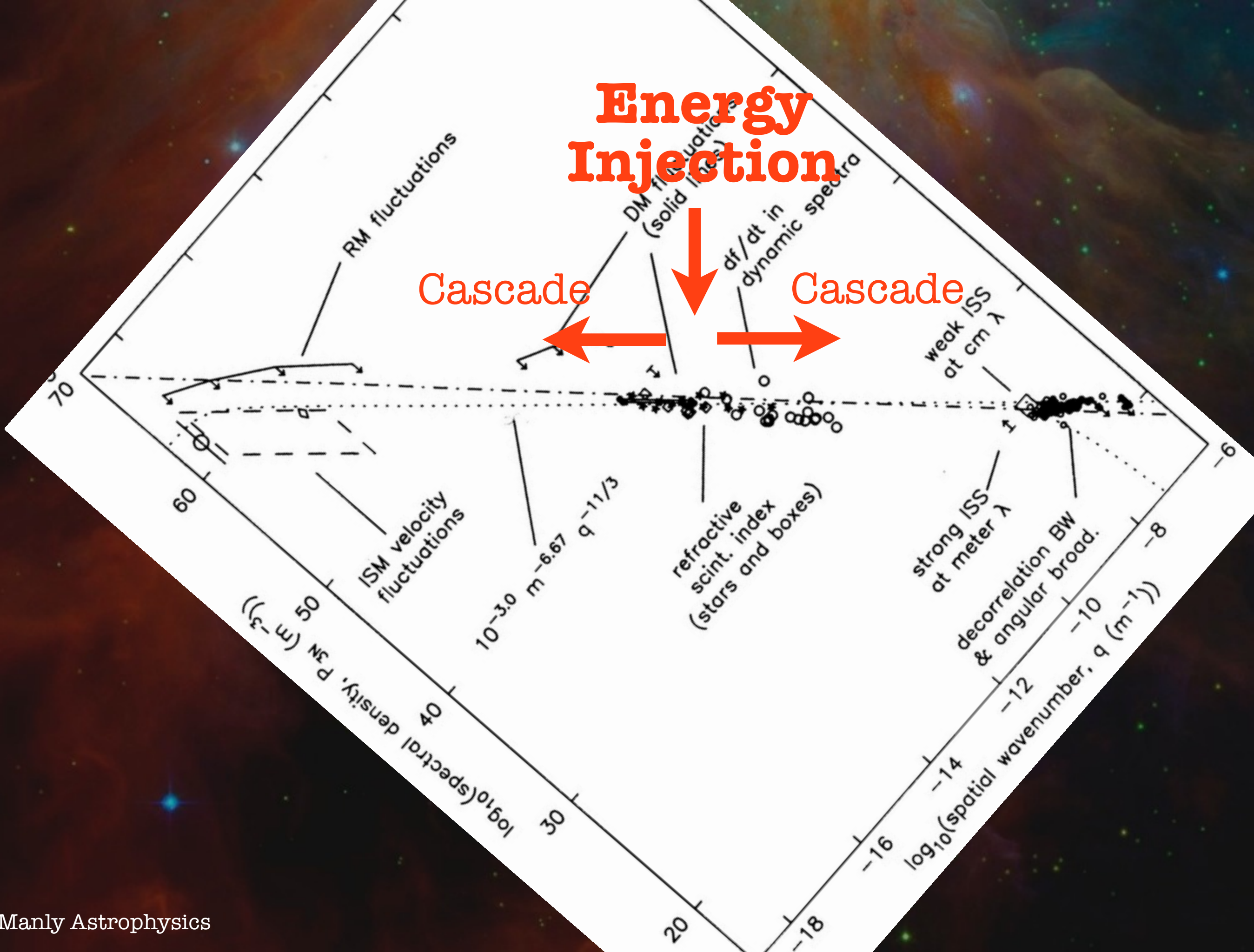


- Is this part of a cascade from large scales ?
- Highly stressed : $P_{\text{ISM}} \ll P_{\text{gas}} \ll P_{\text{B}}$
- Highly concentrated
- Highly ordered

Energy Injection

Cascade

Cascade



Key Points

- Interstellar scattering is highly localised
 - Concentrations $\sim 10^{14\pm1}$ cm in size
- Number density in Galactic disk $\sim 10^4$ pc $^{-3}$
 - Volume filling factor $\sim 10^{-8}$
- Large stresses (gas, magnetic)
- Highly concentrated, stressed, ordered
 - Unlikely to arise amid a turbulent cascade
- But scattering clouds may inject energy
 - Whence a cascade to larger and smaller scales ?