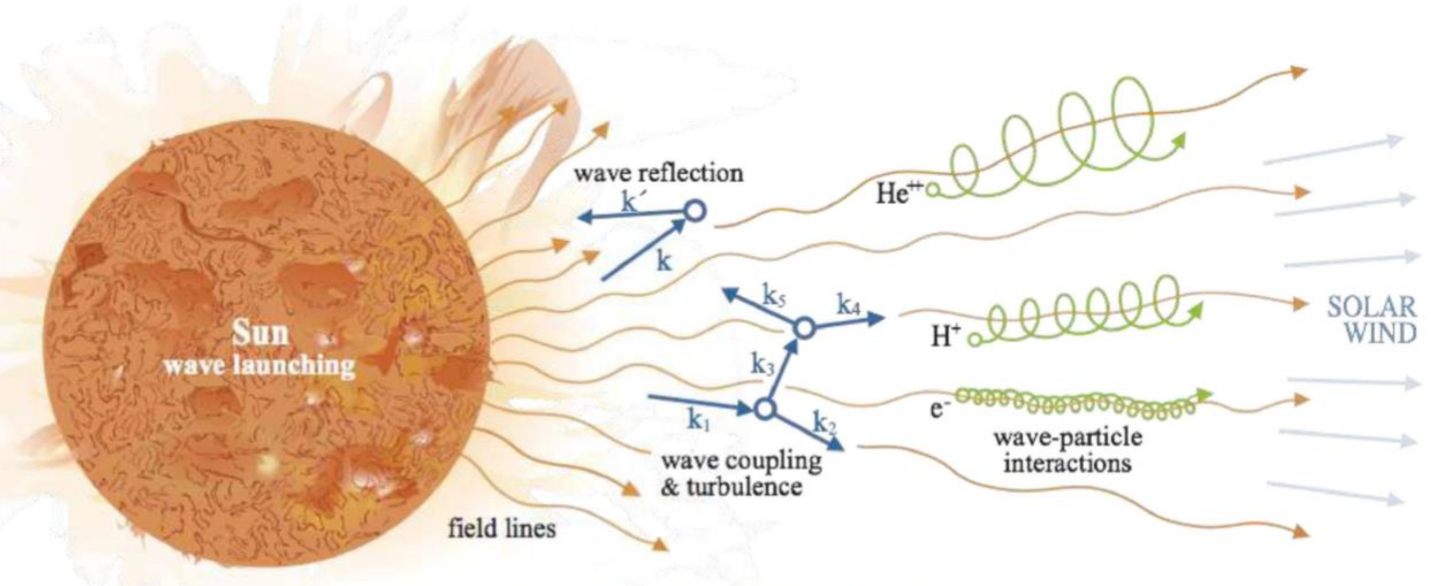
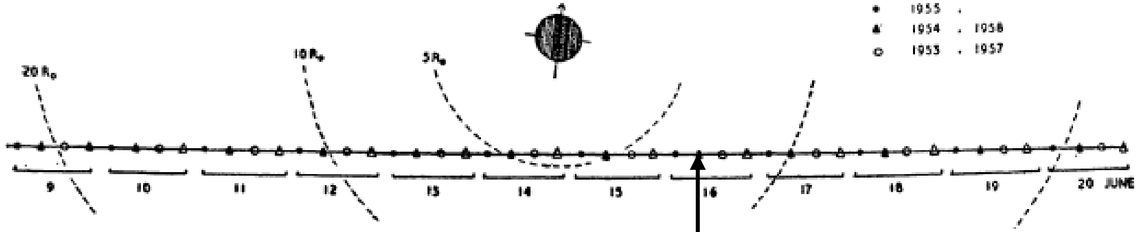
Radial variation of anisotropic density turbulence from the low corona to 1 au and solar radio observations

Eduard P. Kontar, A. Gordon Emslie, Daniel L. Clarkson, Xingyao Chen, Nicolina Chrysaphi, Francesco Azzollini, Natasha L. S. Jeffrey, Mykola Gordovskyy



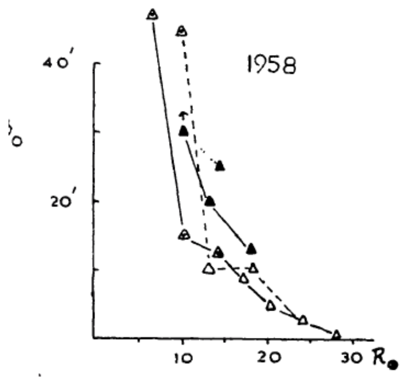
(Lee/Donahue/Chandran)

Sun



Hewish (1958)

Point source (crab nebula)



Size against solar separation

How do density fluctuations change from the Sun to au?

Density turbulence model should be consistent with:

Solar radio burst observations

Broadening/scintillations of (extra-solar) point radio sources via solar atmosphere

In-situ density turbulence measurements

However:

Broadening/scintillations cannot go too close to the Sun

In-situ density turbulence measurements are sparse & far away from the Sun

Solar radio burst observations (type III bursts) are from the low corona to 1 au

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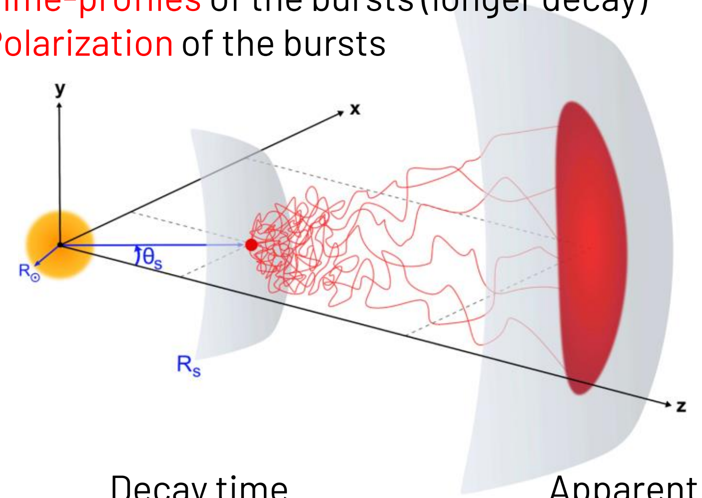
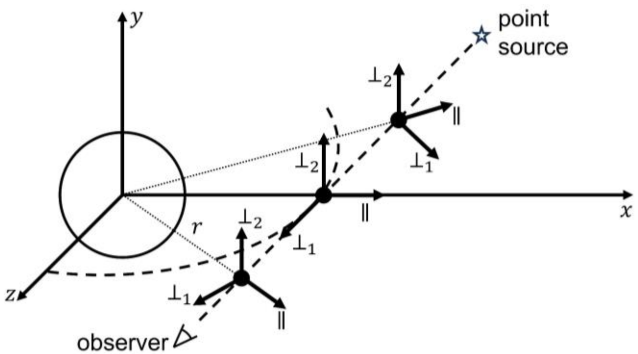
Radio wave propagation affects:

Source position & size (frequency dependent)
Directivity of radio emission
Time-profiles of the bursts (longer decay)
Polarization of the bursts



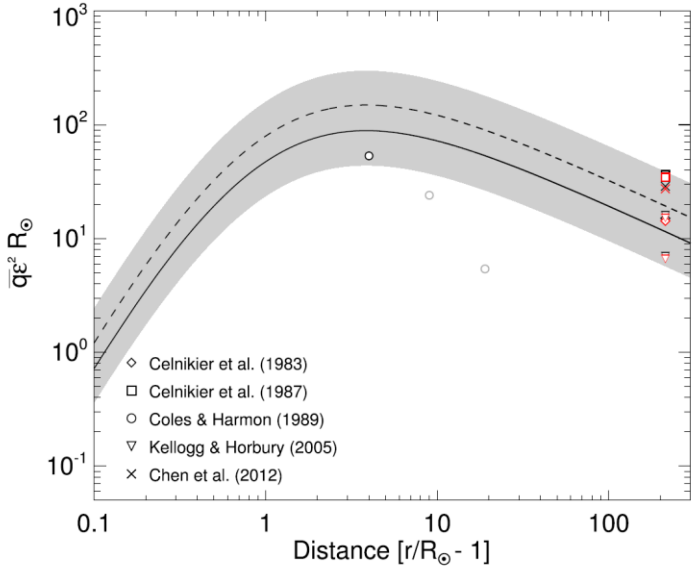
We simulate anisotropic scattering of radio sources and match:

Source sizes & position, time profiles using a turbulence model consistent with in-situ measurements at Earth

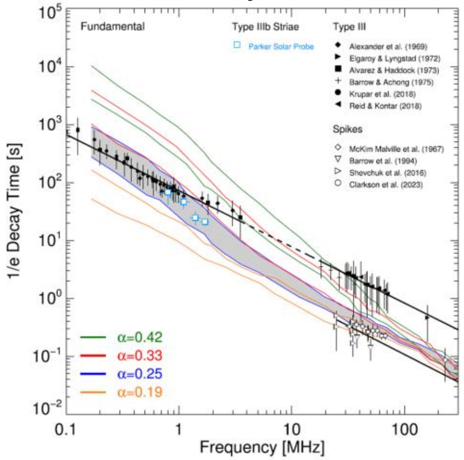


Density turbulence model

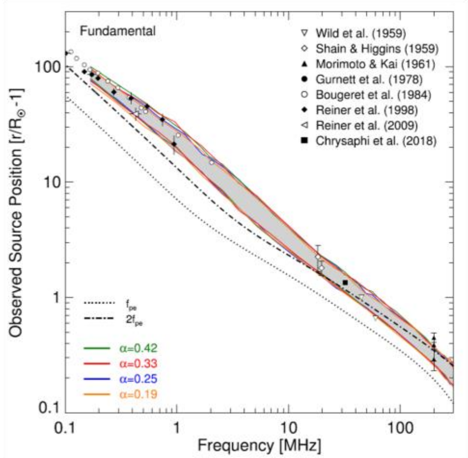
$$\overline{q\epsilon^2}(r)R_\odot = 2\times10^3\alpha\left(1-\frac{R_\odot}{r}\right)^{2.7}\left(\frac{R_\odot}{r}\right)^{0.7}$$



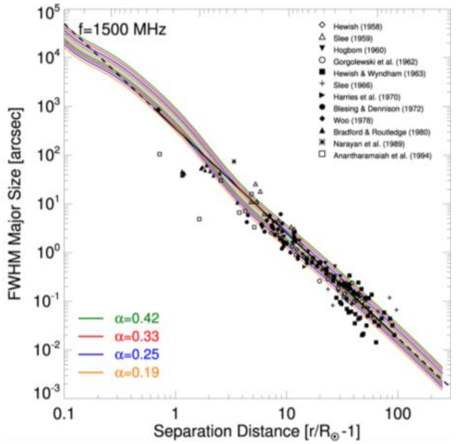
Decay time



Apparent position



Point Source Broadening



The radial turbulence profile has a maximum between 4-7 $R_\odot$ and can account for majority of observations within a factor of 2.

Detailed knowledge of the scattering process paves the way to disentangle the scattering effects from observations, allowing for improved constraint of intrinsic source properties.