Solar type III radio burst fine structure from Langmuir wave motion through turbulent plasma

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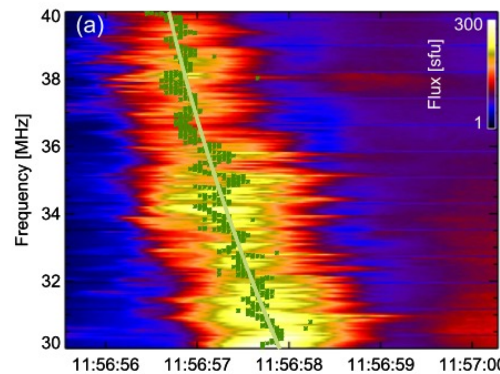
- Type III bursts can exhibit fine structure along their backbone (de La Noe et al 1972), type III striae burst (Fig 1, single stria Fig 2)

- It is believed (e.g. Melrose 1986 as a review) that background electron density fluctuations can modulate Langmuir waves through refraction and cause radio fine structure (e.g. Reid+2010, 2017, Li+2012, Loi+2014).

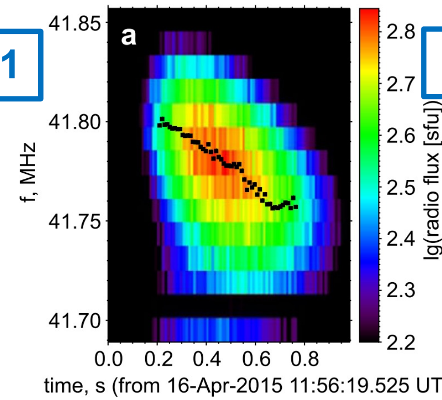
- Chen+ 2018 showed the type IIII radio peak flux (Fig 3) has a power density spectra (Fig 4) with a -5/3 power-law, similar to solar wind.

1



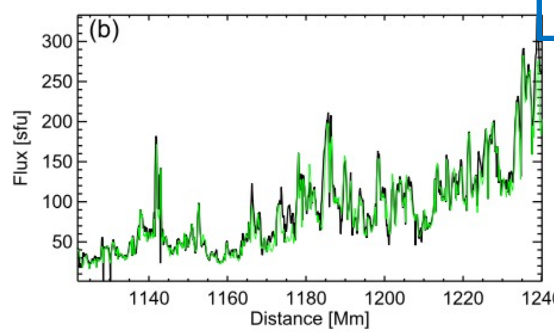
Chen+ 2018

2



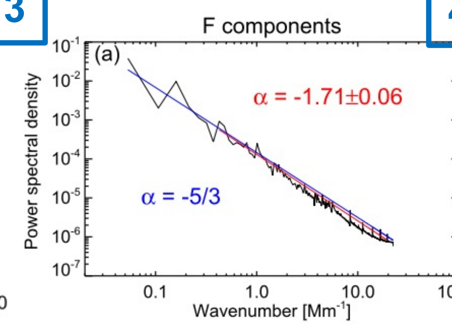
Sharykin+ 2018

3



Chen+ 2018

4



Chen+ 2018

Nobody has created a robust, theoretical model that links the level and spectrum of density fluctuations from the observed radio spectra.

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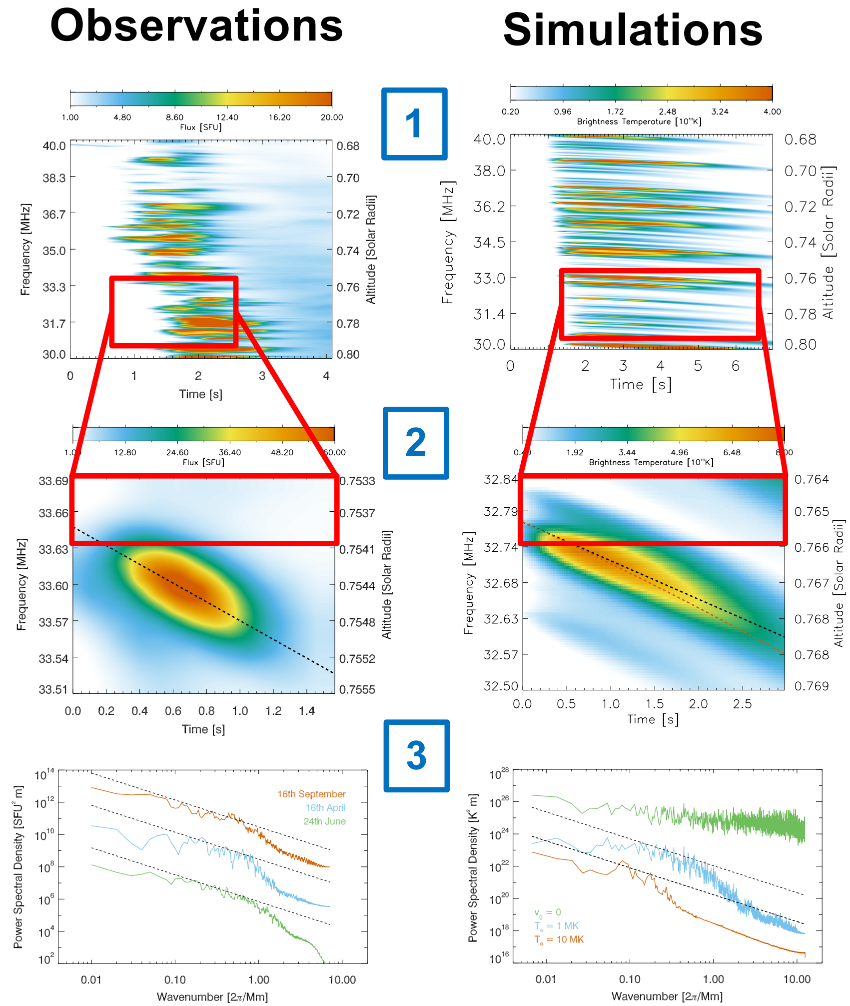
- Background electron density turbulence believed to cause type III radio burst fine structure (Fig 1).
- We show turbulent intensity $\frac{\Delta n}{n}$ related to fine structure $\frac{\Delta I}{I}$ via:

$$\frac{\langle \Delta n^2 \rangle}{n^2} = \left(\frac{v_{Th}^2}{v^2} \right)^2 \frac{\langle \Delta I^2 \rangle}{I^2}$$

- Fine structure frequency drift caused by Langmuir wave group velocity (Fig 2). Group velocity can be estimated by a linear fit to distance vs time.
- Langmuir wave group velocity provides estimates for coronal temperature. We find T=1.1 MK at 1 R_S.
- Thermal and beam velocity used to estimate turbulent intensity. We find $\frac{\Delta n}{n} = 0.3\%$.
- Radio provides estimate of power density spectra electron density, we see -5/3 slope (Fig 3).



Reid & Kontar, Nature Astronomy 2021, https://doi.org/10.1038/s41550-021-01370-8

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- Radio fine structure intensity can provide a diagnostic of the spectra and intensity of background density turbulence via: and we inferred levels around 0.1 - 0.3%.

$$\frac{\langle \Delta n^2 \rangle}{n^2} = \left(\frac{v_{Th}^2}{v^2} \right)^2 \frac{\langle \Delta I^2 \rangle}{I^2}$$

- Fine structure can also constrain the plasma temperature, where we find 1.1 MK plasma at heights around 0.8 solar radii.

- Enhanced resolution of Parker Solar Probe and Solar Orbiter can measure radio fine structure at lower frequencies. Can help infer the radial evolution of density turbulence close to the Sun.

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