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Imaging a U-burst connected with an IP type III burst

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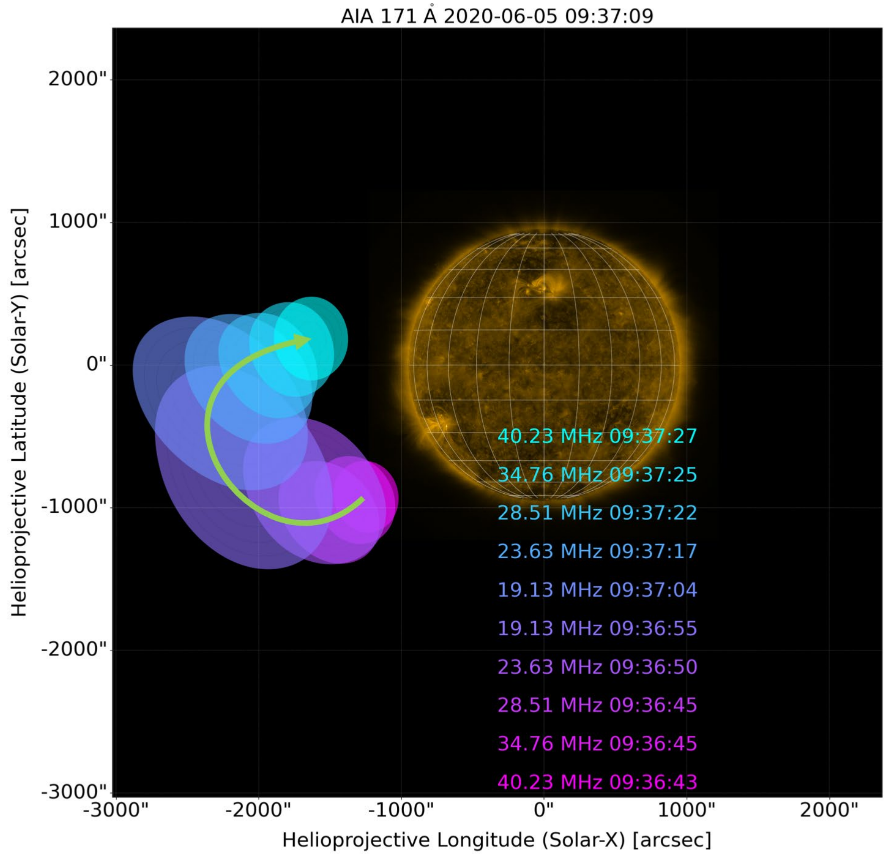
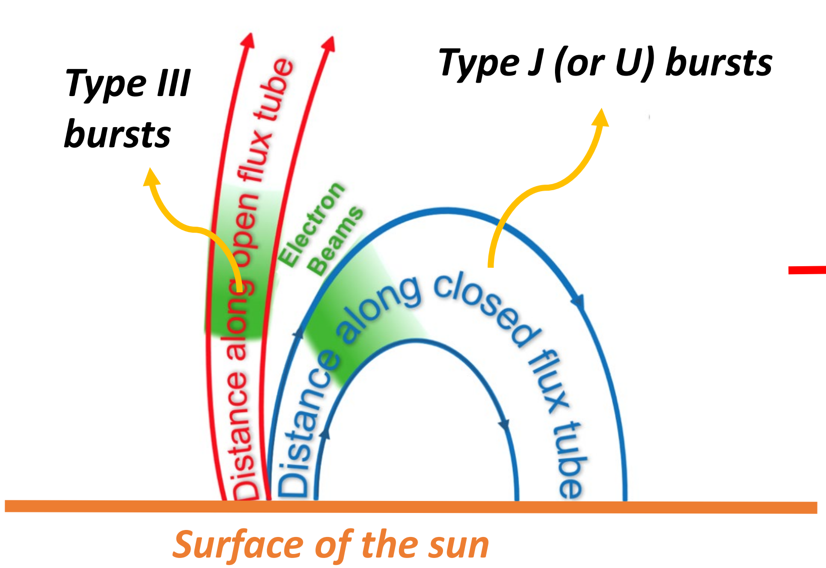
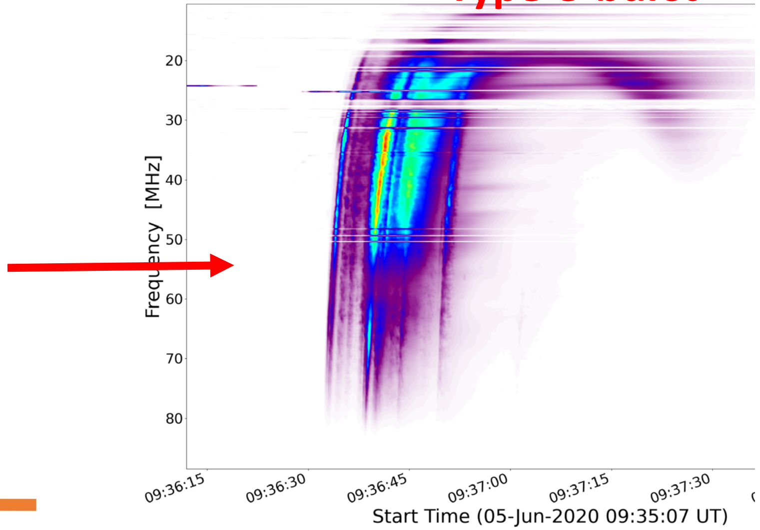


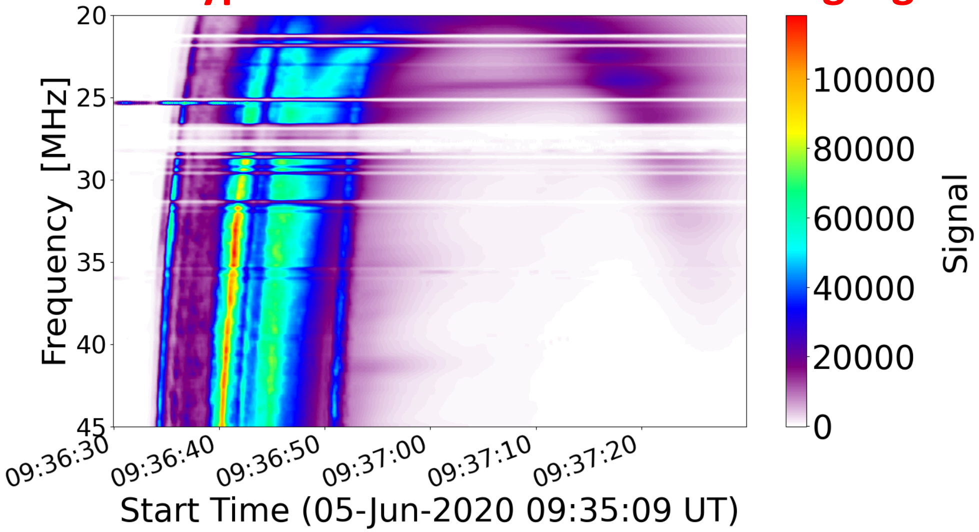
Reid and Kontar, 2017

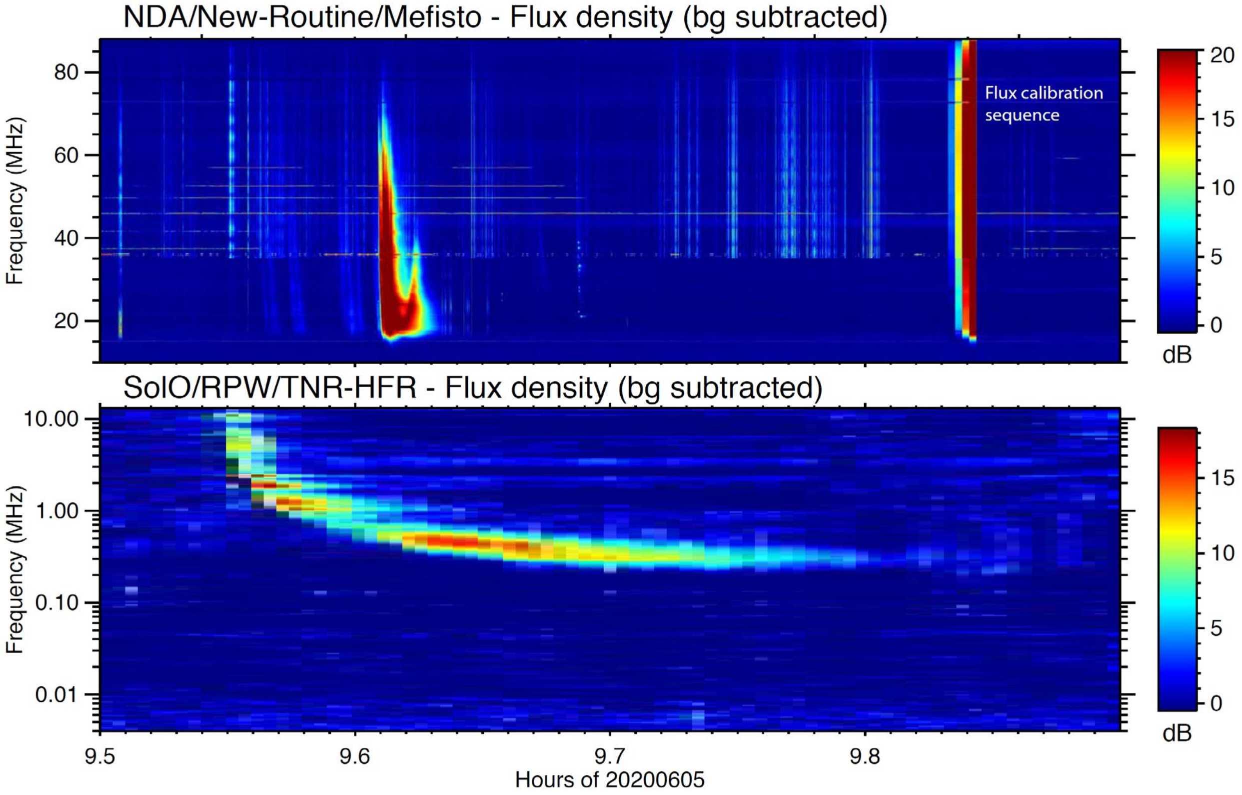


Type U burst



Type III branches in the ascending leg





Observation:

- LOw-Frequency-ARray (LOFAR) and Nancay Decameter Array (NDA) observed **the type U burst on the 5th of June 2020 between 10-80 MHz. Start time at 09:36:30 UT.**
- **This U burst has a very clear descending leg structure, which is rare to see.** We image the U burst from the ascending to descending leg using LOFAR solar interferometric imaging data (24 core stations and 12 remote stations).
- **Simultaneously, an interplanetary (IP) type III burst was observed by Solar Orbiter (SolO) RPW between 0.1-10 MHz.**

LOFAR Interferometric imaging of the U -burst:

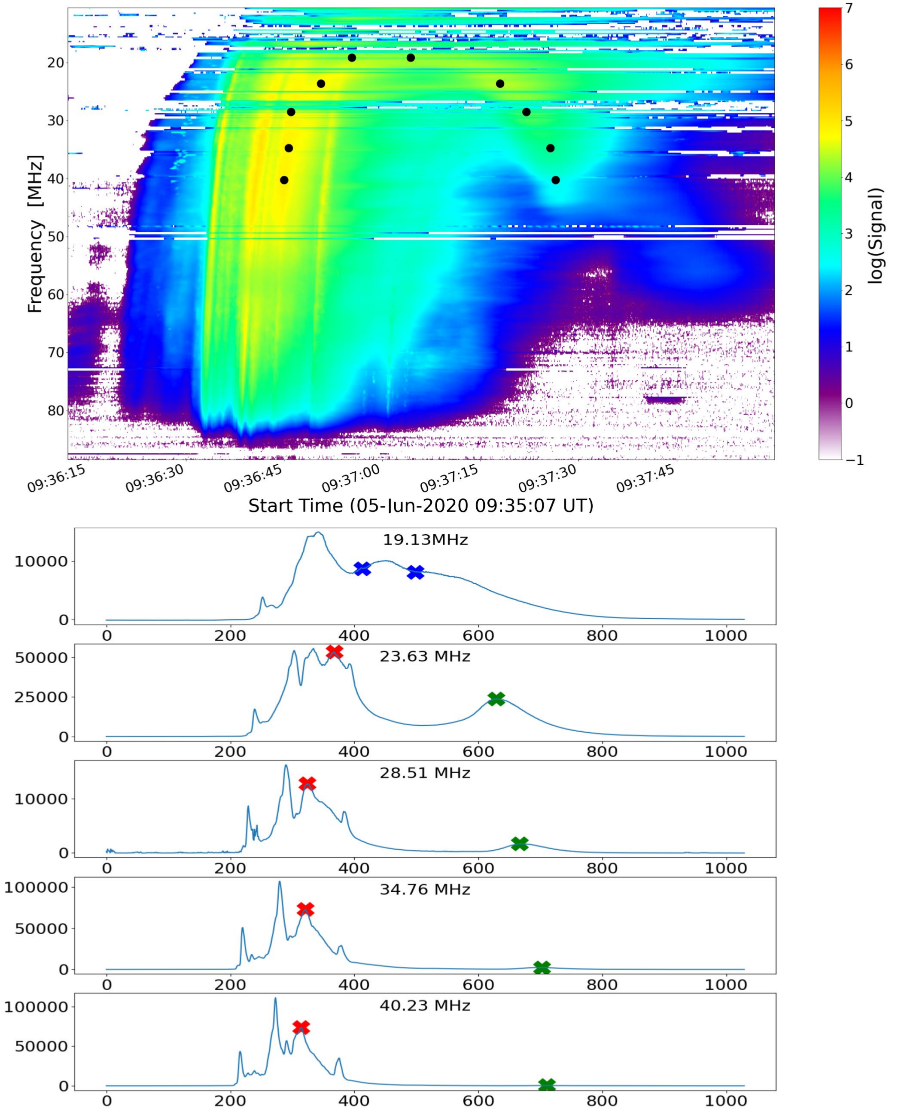


Figure A: The 10 peak flux points we selected for imaging. They are from 5 frequency bands in lower range to see the curved structure of the U burst.

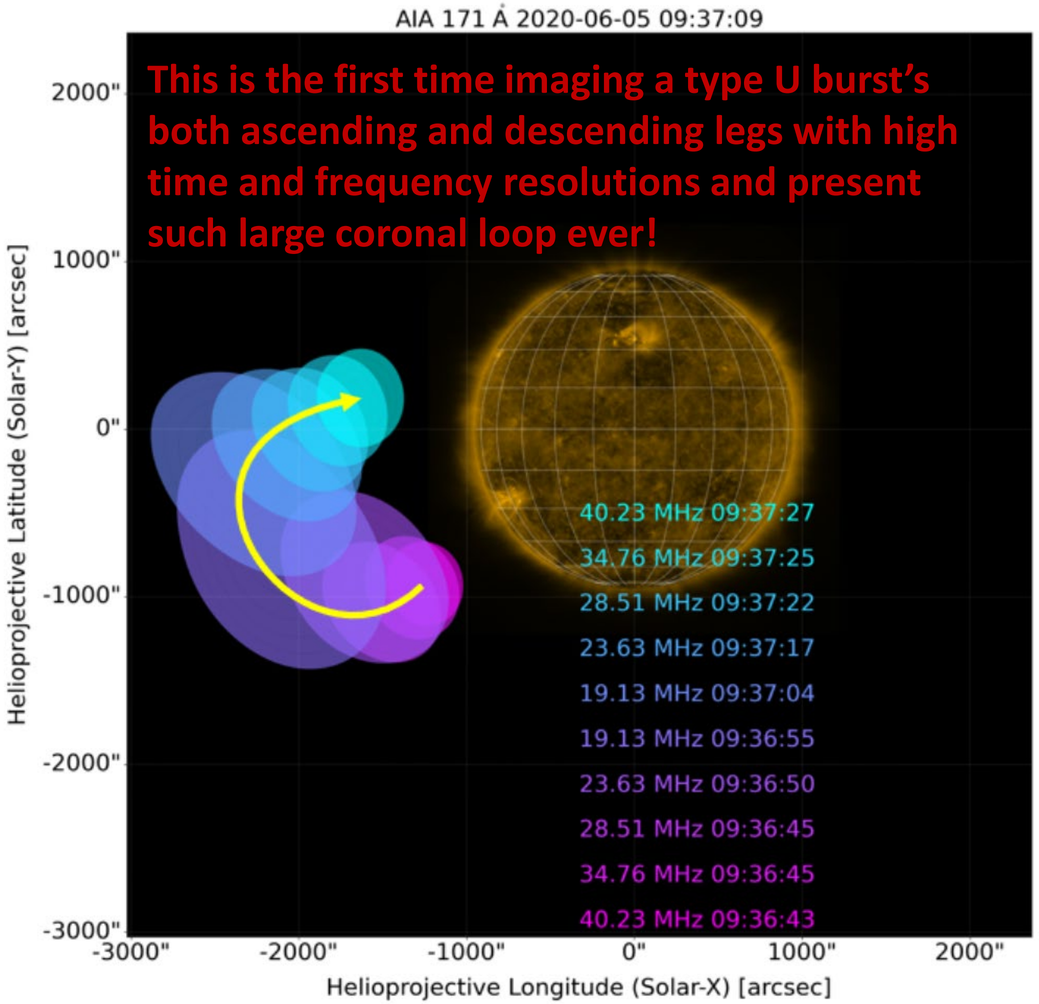


Figure B: Image of the U burst. There are 10 contours, which are source positions of the peak radio flux recorded on the dynamic spectrum (Fig A). The electron beam travels upwards, turns over at the loop apex (19 MHz) and goes downwards.

Electron beam velocities:

Assuming the radio source on the solar limb, we estimate the travel distances of the electron beam from centroids of contours. We derived the average beam velocities for both legs by knowing the time profile from the image.

Coronal loop parameters:

We used the altitude of each radio source to infer the coronal loop's background plasma density model. Therefore the density scale height. Then, use density scale height estimate the loop temperature (in hydrostatic equilibrium), then the ideal gas law and plasma beta to estimate pressure and B field.

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Table 2. Average plasma parameters of large and small coronal loops, near their apex. Large coronal loop parameters were estimated from our 24 low frequency J-bursts, at an altitude of 1.37 $R_\odot$. Small coronal loop parameters were estimated from three high frequency U-bursts analysed by Aschwanden et al. (1992), at altitudes of 0.18 $R_\odot$.

Plasma Parameters	Large Coronal Loops	Small Coronal Loop
Density scale height	0.36 ± 0.07 $R_\odot$	0.51 ± 0.09 $R_\odot$
Density	$(4.5 \pm 1.4) \times 10^6$ cm^{-3}	6.3×10^9 cm^{-3}
Temperature	1.0 ± 0.2 MK	7.0 ± 0.4 MK
Pressure	0.0007 ± 0.0003 dyn cm^{-2}	6.1 ± 0.4 dyn cm^{-2}
Minimum magnetic field strength	$\geq 0.13 \pm 0.03$ G	≥ 12 G

	Ascending	Descending
Coronal Density Scale height	0.34 $\boldsymbol{R_\odot}$	0.49 $\boldsymbol{R_\odot}$
Temperature [MK]	1.75	1.76
Pressure [mdyn cm^{-2}]	0.83	0.84
Magnetic Field Strength [G]	0.14	0.14

Future works on the Interplanetary type III burst and questions:

- There are many type III burst branches in the ascending leg of the U burst, which one are linked to the IP type III burst observed by SolO RPW?
- We can estimate the beam velocities of all type III branches and the IP type III burst. See which one has the most similar kinetic properties.
- We can image the type III branch, we will be able to track the source position of the IP type III burst and see where is the acceleration site.