



Enhancing Triangulation of Interplanetary Type III Bursts through Wavevector Correction

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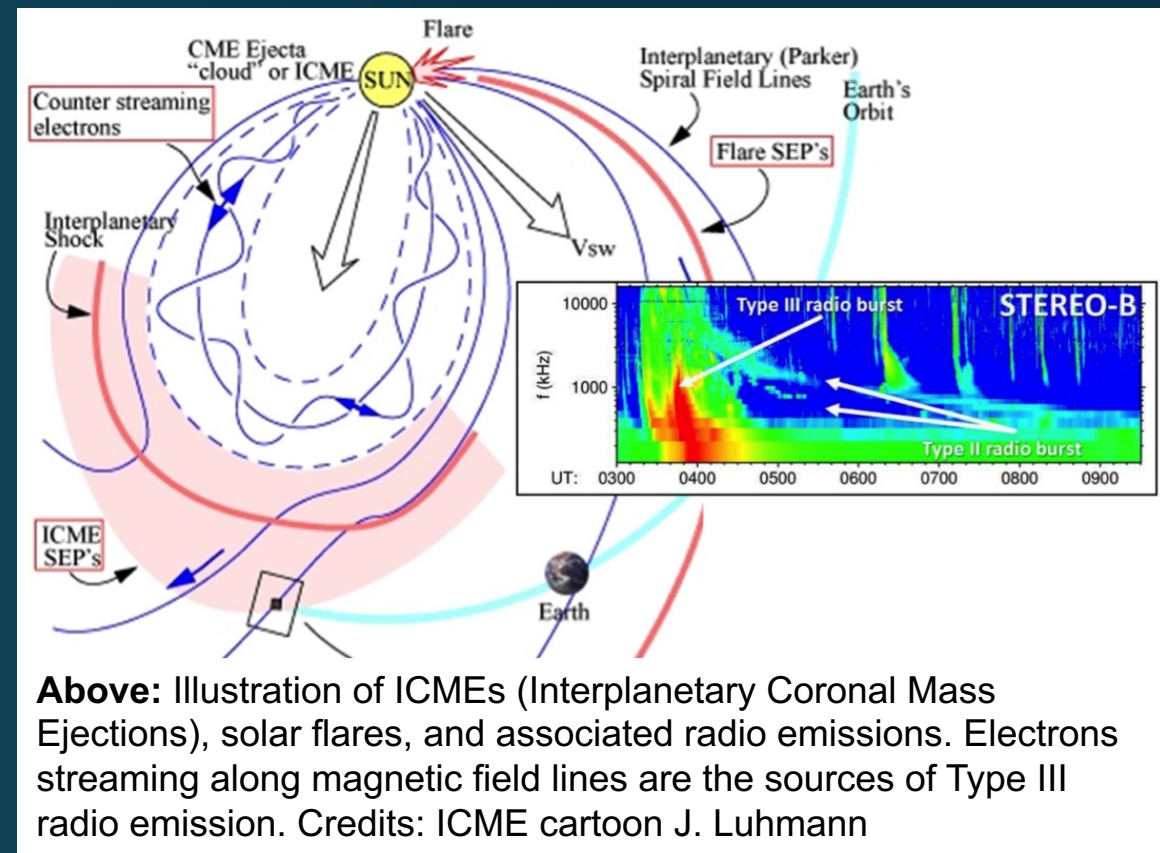
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Background



- Objective: Enhancing the understanding and triangulation of interplanetary Type III solar radio bursts.
- Background: Type III bursts are potent radio signals generated by electron beams at solar flare reconnection sites, key indicators of electron beam activity in solar and interplanetary space. These beams move along the magnetic field and interact with background plasma, producing radio emissions with frequencies dependent on local electron density. By triangulation from multiple points of view we can track them through space and determine the structure of the interplanetary magnetic field.
- Problem: The challenge lies in accurately tracking the origins and paths of these bursts while considering the scattering of the radio waves.
- Hypothesis: Correcting for this scattering will significantly improve our ability to determine the origin of these bursts and thus the electron beams.

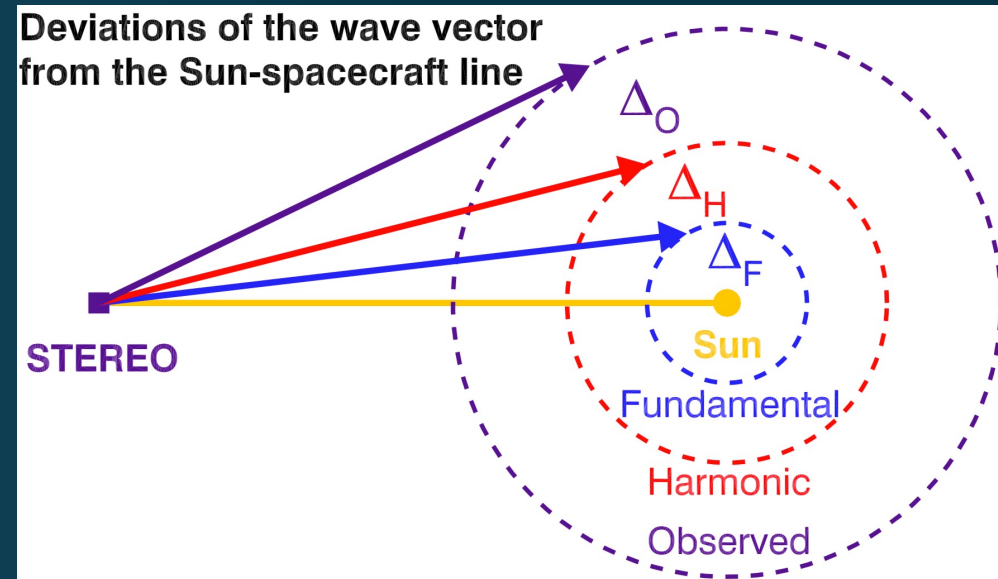




Analysis



- Data and Models: Analysis of 152 instances of Type III bursts observed by the STEREO mission, employing density models and Monte Carlo simulations.
- Analysis Methods: The team compared the computed source locations determined from STEREO-A and STEREO-B using standard models and used the discrepancy between the computed locations to calculate the corrections to those models that would provide a consistent source location as measured by both spacecraft. The correction allowed them to understand how the radio waves were scattered by density inhomogeneities.
- Partnerships: Collaboration with institutions including NASA's Goddard Space Flight Center; University of Maryland, Baltimore County; Université de Toulouse III; Centre National de la Recherche Scientifique; Observatoire de Paris; and University of California, Berkeley.

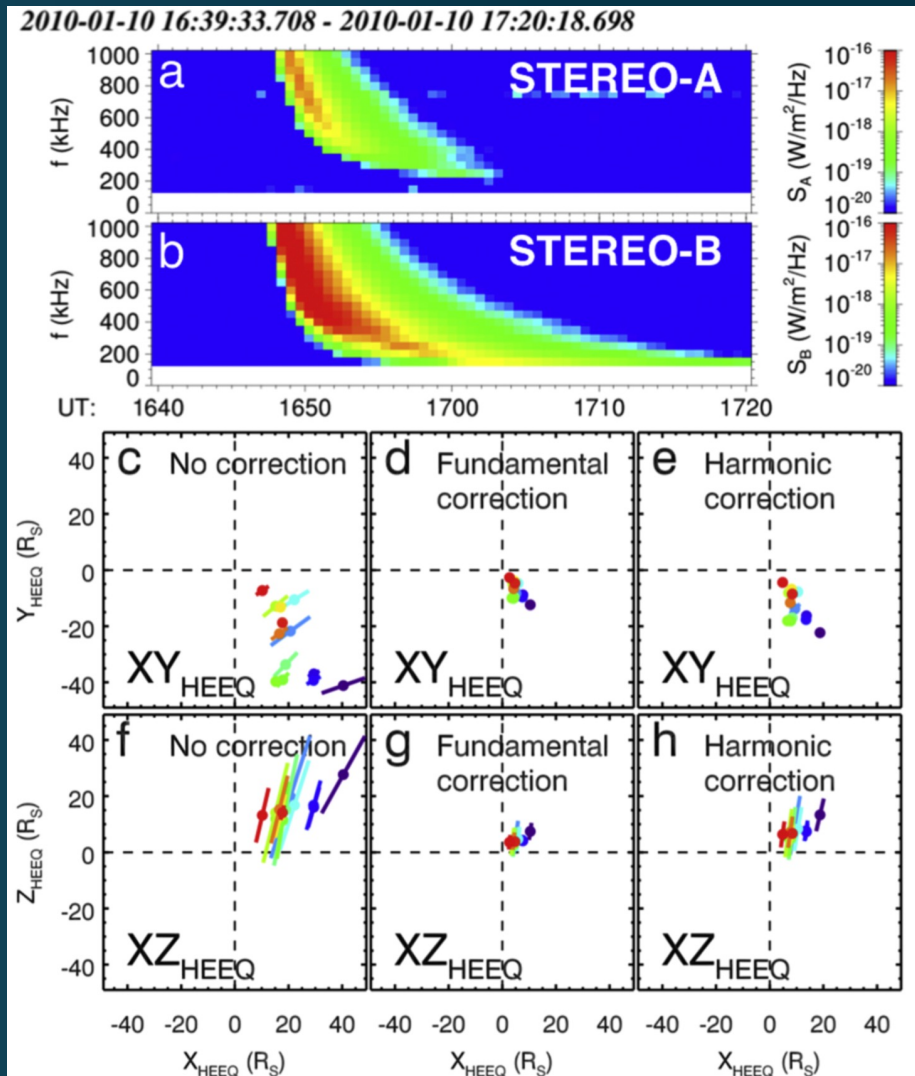


Above: Illustration of wave vector deviations from the Sun–spacecraft line, contrasting observed deviations (in purple) with modeled deviations for emissions at fundamental and harmonic of the plasma frequency (in blue and red, respectively). Without corrections taking into account density inhomogeneities, the radio bursts appear to be coming from locations further from the Sun than is the actual case. *Credits: Krupar et al. (2024)*



Findings

- Analysis Results: Observed discrepancies between the calculated sources of the radio bursts based on standard density models were significantly larger than predicted, indicating scattering effects. The investigators demonstrated that corrected triangulation aligns well with electron beam paths.
- Science Learned: The study confirms the presence of relative density fluctuations in the solar wind of about 40%, impacting burst propagation.
- Lessons: A novel wavevector correction method can enhance triangulation accuracy for these radio bursts.

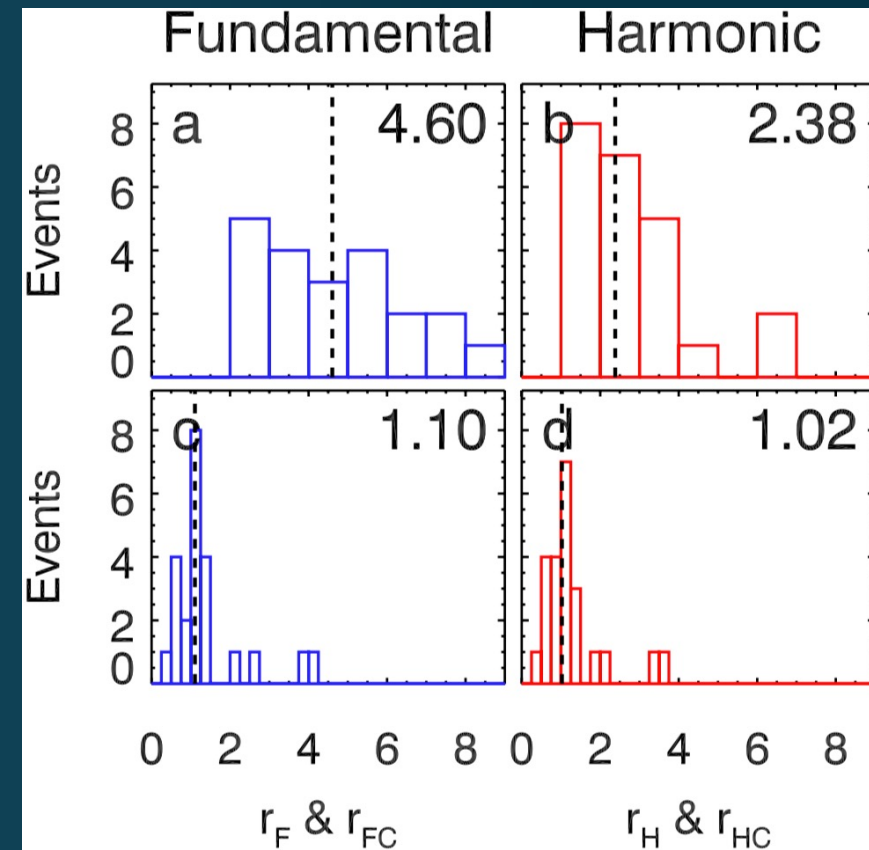


Above: (a) and (b) Radio flux density S for STEREO-A and STEREO-B. (c)–(h) Triangulated radio sources without and with the correction. With the corrections the radio source locations are much more consistent. Krupar et al. (2024)



Impacts

- Science Question: Addresses the challenge of accurately tracking electron beams in the solar corona and interplanetary space so that we can understand the density variations in corona and interplanetary medium and also the magnetic field geometry and paths energetic particles take through the solar system.
- Scientific Community: Provides a new method to improve radio triangulation in space weather studies. This could ultimately enhance our understanding of solar wind dynamics, electron beam propagation, and the overall impact of solar activity on the heliosphere.
- Public Relevance: Enhances understanding of solar activity with eventual ramifications for predicting its potential impacts on Earth and space weather.



Above: Results derived from a statistical survey of 23 type III bursts, showcasing histograms of ratios between electron beam speeds retrieved by radio triangulation without (a and b) and with (c and d) the correction. The correction indicates the radio bursts come from relatively close to the Sun. *Credit: Krupar et al. (2024)*



Publication Information



“Enhancing Triangulation of Interplanetary Type III Bursts through Wavevector Correction”
Enhancing Triangulation of Interplanetary Type III Bursts through Wavevector Correction

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