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Abstract

Plasma Mirrors, Sad Trombones, and Aperiodic Fast Radio Bursts

While long-period activity windows of weeks to months have been identified in two repeating FRBs, the general absence of fast periodicities ($\sim$ sub-second to tens of seconds) is notable, especially given the high burst rates up to 100 hr^{-1} in a few cases. Bursts from repeaters often show the non-dispersive frequency drifts that are negative, $d\nu/dt < 0$ that are also distinctive. In recent work with Ira Wasserman and others, it was shown that free precession could prevent detection of an underlying spin periodicity in low-rate burst trains extending over days to months but would not deter periodicity detection in high-rate sequences. To mask such periodicities, arrival time variations greater $\sim P_{\mathrm{spin}}/3$ are needed and we suggested emission altitude variations up to the light-cylinder radius $r_{\mathrm{LC}} = cP_{\mathrm{spin}}/2\pi$ as one such cause.

As an alternative, I have been making a preliminary study of the role of plasma mirrors in the local environment of the central engine (which I take to be a young magnetar). Reflections off such mirrors cause propagation distances to lengthen, most likely stochastically, and a moving mirror will Doppler shift emission from the source to higher or lower frequencies. Multiple reflections will increase both the propagation arrival times and Doppler shifts. If mirrors tend to move away from the source, apparent drift rates between multiple reflected bursts can show the observed trend with $d\nu/dt < 0$ and at the same time erase any imprint of the spin periodicity in observed burst sequences.

While a real model is not yet developed, ideas about source and mirror configurations include: (1) opening of propagation channels by high-intensity beamed flares that drive through a surrounding nebula nonlinearly, allowing radio bursts to propagate and reflect off of channel walls; (2) fragmentation of the nebula (or channel walls) into 'island' mirrors with differential motions that provide multiple propagation paths. Motion of the source relative to a surrounding nebula (e.g. from a velocity kick or orbital motion) may be involved with making mirrors that recede from the source in order to get negative frequency drifts. Next steps include calculation of reflection and transmission coefficients through mirror structures. An intriguing possibility is that polarization-dependent reflections (or transmissions) can alter the polarization state of the source's emission. This may favor one of the polarization states to reach an observer, perhaps accounting for the constancy of polarization angles across bursts in some cases.

Bio: I have been a professor in the Astronomy Department at Cornell since 1979 and a member of the Cornell Center for Astrophysics and Planetary Science. My interests include neutron stars manifested as pulsars, magnetars, and fast radio bursts and their effects on local environments, such as pulsar wind nebulae. Propagation effects in plasmas near and far (IPM, ISM, IGM, CGM) and from gravity are a long-time focus of my research. As well as providing information about the media themselves, I have worked on the characterization and mitigation of plasma dispersion and scattering for precision pulsar timing required for the NANOGrav collaboration's goal of detecting and exploiting parsec-wavelength gravitational waves. My observational work is primarily at radio wavelengths but recently has included *in situ* measurements from the *Voyager* spacecraft. I develop and use a variety of signal processing and statistical inference methods and am currently exploring various machine learning methods. Propagation phenomena seen from pulsars are also relevant to SETI, another area that I have worked in and expect to continue. Our group at Cornell is engaged with the DSA-2000 (Deep Synoptic Array) project for our interests in NANOGrav and FRBs and the GREX (Global Radio Explorer) project as a means for detecting local FRBs. Finally I am writing a book *Astro-optics of the Magnetoionic Universe* that will cover the physics and empirical aspects of propagation effects and their application to precision pulsar timing, FRBs, and SETI and other contexts.