Radio Interference Excision: A Pulsar Observer's Perspective

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The temporal and frequency variability of pulsar signals make their observation particularly vulnerable to radio frequency interference. Pulsar observations are made over wide bandwidths at low frequencies (typically between 0.4 and 2.4 GHz), often outside the protected bands. Interference from radar installations, television stations, and other terrestrial sources are a perennial problem.

From an RFI perspective, the most challenging pulsar observations are searches in which neither the pulsar rotation frequency nor its dispersion measure (chirp rate) are known. The data sets are time series of 10^6 to 10^8 spectra, sampled at intervals under 1 ms, each with 10^2 to 10^3 spectral channels. Fourier and other techniques are used to detect swept periodic signals within the data set. Several steps must be taken to mitigate RFI:

1. Monitor the passband in real time with a spectrometer and chart recorder. In cases of severe interference, reallocate the telescope time to some other project.
2. Search for and remove broadband spikes in power with time resolution of order 0.1 second. The most prominent such sources are radar transmitters and lightning.
3. Examine spectra for excess power in single channels on time scales of seconds or minutes. The most prominent sources are communications carriers.
4. After Fourier transforming the time series, excise known RFI frequencies such as the 60 Hz power line, 1.2 Hz cryogenic pumps, etc.
5. Delete RFI-prone portions of the data at long periods (greater than a few seconds) and small dispersion measures.
6. If the observations cover a series of different telescope pointings made in sequence, search for (and remove) repeated detections of the same candidate pulsar frequency at different sky locations.
7. Manually examine the data after the fact for repeated detections of the same frequency at widely separated points.

All of these steps hinge on the assumption that RFI is confined to particular ranges of frequency and/or time. Increased use of spread spectrum techniques will make RFI more difficult to remove.

Searches for single (non-periodic) pulses are particularly difficult because single pulses are easily mimicked by RFI. Dispersion of astronomical signals is key to distinguishing them from (un-dispersed) terrestrial signals.

Observations of pulsars with known periods are somewhat less vulnerable to RFI (since the signal is naturally "switched"), and steps 4 through 7 above are typically not needed. Still, we have found basic time and frequency domain RFI excision leads to distinct improvement in the quality of such observations. Data acquisition systems based on baseband detection and software analysis are particularly well suited to this task.