Automated Radio Astronomy Observations with the NASA Deep Space Network

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While NASA's Deep Space Network is designed and operated for deep space telecommunications, the antennas are also very capable radio telescopes. The 70-m antenna near Canberra, Australia, is the most sensitive centimeter wavelength telescope in the southern hemisphere. Some fraction of the time on DSN antennas is scheduled for radio astronomy observations in support of NASA's science goals and treaty obligations with the host countries Australia and Spain. We are in the second year of a three-year effort to automate radio astronomy observations. At this stage, we are focusing on using unscheduled 70-m time. The software examines the DSN schedule for gaps, generates requests to assign these gaps to radio astronomy, assesses the suitability of a gap for the various projects supported, selects a project, generates the files and operational messages needed to carry out the observations and performs the first level of post-processing. Currently, we are using DSN recorders which directly sample the intermediate frequency signals so that post-processing consists of producing de-dispersed time series for pulsars and high time and frequency resolution spectra for spectral line astronomy. A website is automatically updated as the steps are completed.

We have found that there are usable schedule gaps, defined as two hours or longer, almost every day at each 70-m antenna so that we are now using about 10% of the DSN 70-m time for automated observing. This is in addition to the time scheduled directly for astronomy, which is on the order of 5%. The amount of data generated exceeds the storage capacity of the DSN recorders, so we are deploying high performance computers with 140TB of working disk storage to each of the DSN stations. The goal is to keep the raw voltage samples for a few months to allow the PI to perform basic data quality checks, try various RFI removal strategies and do the first level data reduction including dispersion measure searches for transient astronomical signals before transport to the principal investigator's home location.

A separately developed program called the DSN Transient Observatory (Kuiper *et al.*, 2016, submitted to J. Astr. Instr.) which examines the DSN down-link bands while antennas are receiving telemetry from deep space missions will also be integrated so that commensal radio astronomy observations will also be entirely automatic, up to the level of reduction specified by the PI. In this phase of the work we will be incorporating radio astronomy back-ends which have a separate monitor and control system (Kuiper it et al., J. Astron. Instr., in preparation 2016).

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