Pulsar Timing for Undergraduates: Research Meets Outreach

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Abstract

The Pulsar Observers at UVA, consisting of 16 undergraduate students, uses the Long Wavelength Array to observe and construct a timing solution for 10 pulsars over the course of a year. Each of the pulsars we observed has either not had a pulsar timing solution published before, or its timing solution was published longer than 30 years ago. Since many of our members have no prior research experience, we are able to use our group as a platform for outreach among the undergraduate community, providing students with valuable research experience while giving them the opportunity to perform non-trivial scientific activities.

Group Structure

Our group works independently with long-distance guidance from our mentor Dr. Kevin Stovall. Students learn about pulsar timing through talks with radio astronomers, Kevin Stovall and Scott Ransom, and through instructional lectures by our student leader, Steven Stetzler. All work is documented on our group website.

Video conferencing and in-person lectures provide introductory information on

- Working with the command line
- Processing observations from the LWA to search for pulsars
- Searching for a removing RFI in data
- Modifying pulsar data to create pulse profiles
- Generating Time of Arrivals (TOAs) from observations
- Producing timing solutions

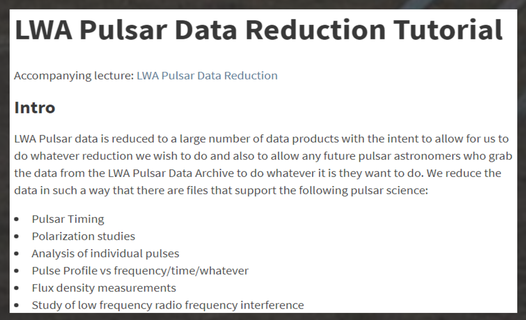
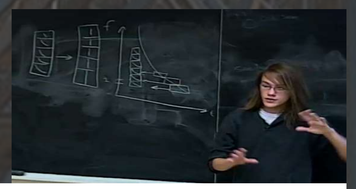
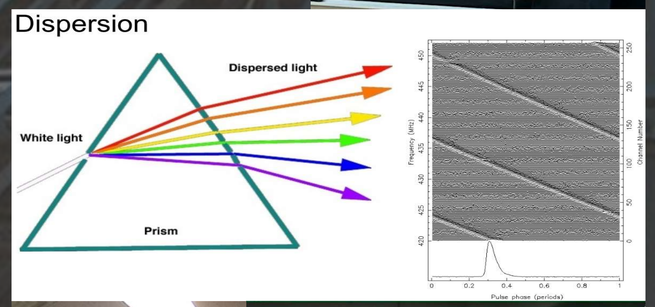


Figure 1: Text based tutorials are also available online for later reference.





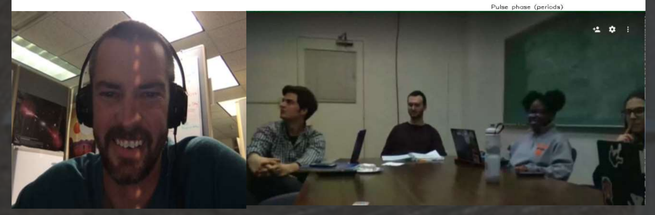


Figure 2: Conference calls and in-person lectures provide students with introductory information on pulsars.

Expansion of the Group

Since our work is shared online and inherently instructional, anyone can join at any time from any distance. This structure in a research group allows for us to expand to other institutions. Alumni of this program can continue to lead this group at UVA or can create a new group at the graduate schools that they attend, piggybacking on what we have already built.

Observations of Pulsars

We observed 10 pulsars using the Long Wavelength Array over the frequency range of 25 - 89 MHz. New observations and archival LWA data were used to construct the timing solution for these pulsars. A list of observed pulsars is contained in Table 1.

Unpublished Pulsars	Binary Pulsars	Retimed Pulsars	
J0611+30	B0655+64	B1504-43	B1133+16
J1929+00		B0950+08	B0823+26
J2227+30	B0820+02	B2016+28	B2020+28*

Table 1: The list of our target pulsars.
*B2020+28 is an extra pulsar in the beam of B0823+26.

Results

Preliminary timing solutions have been made for pulsars J2227+30 and B1133+16. Plots of their post-fit residuals and initial values for their solution parameters are shown in Table 2.

J2227+30

F	1.1871
$\dot{F}$	-1.1667
RAJ	$22^h27^m42^s$
$DECJ$	$30^\circ38'23''$
DM	19.963

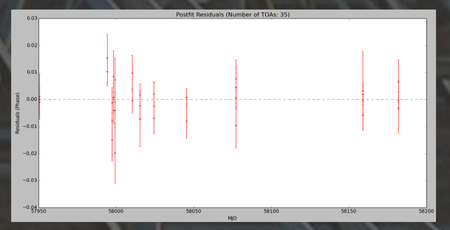


Figure 3: Post-fit residuals for J2227+30. Weighted RMS = 4200 μs

B1133+16

F	0.8418
$\dot{F}$	-2.6366
RAJ	$11^h36^m03^s$
$DECJ$	$15^\circ51'06''$
DM	4.847

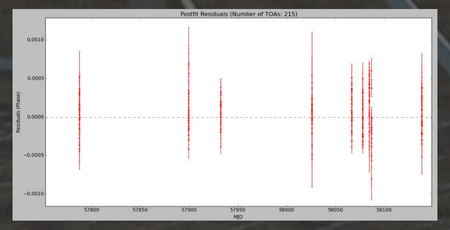


Figure 4: Post-fit residuals for B1133+16. Weighted RMS = 300 μs

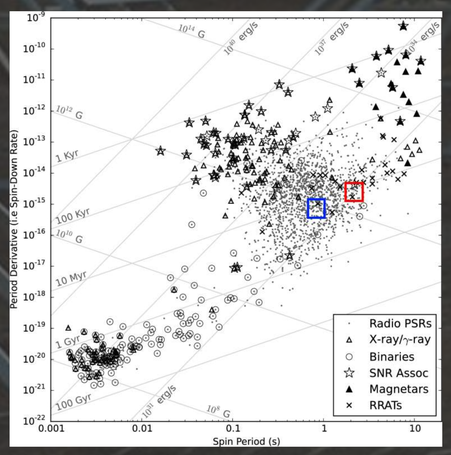


Figure 5: The location of J2227+30 (Blue) and B1133+16 (Red) in the $P - \dot{P}$ plane

Acknowledgements

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