Spin Frequency and Harmonics of Pulsar J1909+0254
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Introduction
The research I conducted during the 2012-2013 school year consisted of the analysis of fifty-four pointings. These pointings were made up of approximately 1,890 individual plots. From this body of work, I discovered one previously discovered pulsar, J1909+0254. The remaining plots were either RFI or natural interference.

I focused on different aspects of J1909+0254 and it became apparent that J1909+0254 exhibited frequency harmonics. My poster is a presentation of five frequency harmonics of this pulsar, which gives a very thorough and complete illustration of the pulsar at different spin frequencies. A pulsar is a rapidly spinning neutron star emitting radio waves in two directions opposite to each other as it spins. If we are in the path of these radio waves, a radio telescope, in this instance, the Green Bank Telescope of the National Radio Astronomy Observatory (NRAO) of Green Bank, West Virginia, can receive their signal and transfer that information onto a graph that can be analyzed.

Presented are the Prep-Fold plots and a Single-Pulse plot for J1909+0254. Also presented are my base calculations for the spin frequencies of each harmonic of this pulsar.

Equations

Frequency
\[ f = \frac{1}{\text{Time}} \]

Spin Frequency
\[ f_{\text{spin}} = \frac{1}{P_{\text{spin}}} \]

Spin Frequency Calculations for Harmonics of J1909+0254

Harmonic 1
\[ f_{\text{spin}} = \frac{1}{0.9899} = 1.010 \text{ Hz} \]

Harmonic 2
\[ f_{\text{spin}} = \frac{1}{0.4949} = 2.021 \text{ Hz} \]

Harmonic 3
\[ f_{\text{spin}} = \frac{1}{0.2828} = 3.536 \text{ Hz} \]

Harmonic 4
\[ f_{\text{spin}} = \frac{1}{0.1414} = 7.072 \text{ Hz} \]

Harmonic 5
\[ f_{\text{spin}} = \frac{1}{0.05824} = 17.17 \text{ Hz} \]

Harmonics
When working in the frequency domain, we can also take advantage of harmonics. We say that the spin frequency is the fundamental or first harmonic. The second harmonic occurs at twice the frequency of the first harmonic, the third harmonic occurs at three times the frequency of the first harmonic, and so on. Mathematically, the frequency of the \( n \)th harmonic is \( n \times f \), where \( f \) is the spin frequency. Harmonics occur naturally almost any time there is a periodic signal.

Musical instruments, like violins, pianos, or the human voice, produce sound waves, and waves are periodic. So when a violin player plays a note, such as an A-flat, what you hear is actually all the harmonics of an A-flat. These higher harmonics give the instrument a rich, pleasing sound, and cause it to sound like a violin instead of some other instrument, such as a piano, which would have a different harmonic structure.

Harmonics add a richness to pulsar signals as well. Some, and often quite a bit, of the power from a pulsar signal is in the higher harmonics. If we only used the first harmonic (the spin frequency), then we would lose sensitivity, especially to weak pulsars.