Contribution ID: **35** Type: **Contributed Talk**

# Visualizing the pulsar population using graph theory

*Tuesday 11 October 2022 16:00 (15 minutes)*

The $P\dot{P}$ diagram is a cornerstone of pulsar research. It is used in multiple ways for classifying the population, understanding evolutionary tracks, identifying issues in our theoretical reach, and more. However, we have been looking at the same plot for more than five decades. A fresh appraisal may be healthy. Is the $P\dot{P}$-diagram the most useful or complete way to visualize the pulsars we know? Here we pose a fresh look at the information we have on the pulsar population. First, we use principal components analysis over magnitudes depending on the intrinsic pulsar's timing properties (proxies to relevant physical pulsar features), to analyze whether the information contained by the pulsar's period and period derivative is enough to describe the variety of the pulsar population. Even when the variables of interest depend on $P$ and $\dot{P}$, we show that $P\dot{P}$ are not principal components. Thus, any distance ranking or visualization based only on $P$ and $\dot{P}$ is potentially misleading. Next, we define and compute a properly normalized distance to measure pulsar nearness, calculate the minimum spanning tree of the population, and discuss possible applications. The pulsar tree hosts information about pulsar similarities that go beyond $P$ and $\dot{P}$, and are thus naturally difficult to read from the $P\dot{P}$-diagram. We use this work to introduce the pulsar tree website http://www.pulsartree.ice.csic.es containing visualization tools and data to allow users to gather information in terms of MST and distance ranking. We also discuss applications of these techniques to the Fermi-LAT pulsar catalog.

## Track

Pulsars

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**Session Classification:** Parallel 6