Using Radio Emission to Detect Unknown Quiescent Black Holes and Pulsars

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Introduction

Quiescent black holes produce large amounts of synchrotron radiation within the radio band due to the presence of the black hole's powerful relativistic jets. Here, we describe a method of locating unknown stellar mass black holes by using two radio sky surveys: VLASS and NVSS. During this process, an interesting offshoot became evident. The steep spectrum point sources within the list may be indicative of unknown pulsars.



Identifying Quiescent Black Holes Using Radio Sky Surveys

Total_flux/Peak_flux

Astrophysical jets emanating from black holes produce synchrotron radiation which can be detected by looking for flat spectrum sources and eliminating sources with slopes significantly steeper than -0.7

Using two radio sky surveys, NVSS and VLASS, allows for the spectral index to be determined for each source.

Method

Some matches were bound to occur by chance, so we predicted that the optimal match radius would be around 23 arcseconds.

Within the outliers, the active galactic nuclei Hydra A¹, was present. Although it is not quiescent, its image illustrates the relativistic jets quite well.





Identifying Pulsars Using Radio Sky Surveys

Pulsars, unlike the flat spectrum synchrotron radiation, have steep spectrum, so within the steeper sources, there should be a large amount of previously undiscovered pulsars.

Method

The list of matches between VLASS and NVSS was matched to the ATNF Pulsar Catalogue which contains 2,546 pulsars. The match yielded 61 sources, and, as expected, the list contains a significant number of steep sources.

We are currently in the process of investigating each individually and have already noticed some strange objects.

PSR J0358+5413 and PSR J0034-0721 both have oddly positive spectral indices. For the former, this could be explained by a wind nebula², but the latter object's variation between the two VLASS epochs is either due to strong scintillation or an extreme scattering event³.

Summary

Analyzing the spectral indices of radio sources from two sky surveys creates a method to search for previously unknown black holes and pulsars. Although the technique is still in the beginning stages, it certainly represents a potential method for discovering more of the extreme objects hidden within the universe. Finding more of these extreme objects will ultimately increase the knowledge of complex systems such as jet production mechanisms and accretion onto stellar remnants.

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PSR J0034-0721 in first VLASS epoch

PSR J0034-0721 in second VLASS epoch

