Keywords:
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Searching for bright compact needles in a radio haystack of galaxies and stars

Unlocking the Mysteries of Fast Radio Bursts (#FRBs) and Compact Radio Sources through Innovative Data Analysis and EOSC Integration

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"The FRB community has been steadily growing since 2007, having a major annual conference, along with regular meetings and workshops. The field now covers various aspects ranging from theoretical modelling of likely progenitors and their emission mechanisms; observational methods, radio telescopes design, and algorithmic advancements; studies of host environments to FRBs; multi-wavelength and multi-messenger studies; and using FRBs as probes of the interstellar medium, circum-galactic medium, and potentially to cosmology."

The Project Involved

The discovery of fast radio bursts (FRBs) is one of the most intriguing radio astronomical discoveries of our time. FRBs are short (faster than the blink of an eye) and energetic (as much energy in a few milliseconds as the Sun outputs in a day) radio flashes originating from outside our Milky Way galaxy. The nature of FRBs remains elusive, but causality arguments based on the short duration of these bursts imply a compact origin. Furthermore, a detection of FRB-like emission from the Galactic magnetar SGR 1935+2154 hints towards a neutron star origin. From the handful of FRBs that have been localized to a host galaxy, two published cases have been associated with compact, persistent radio sources (PRSs). Both display a characteristic broadband synchrotron spectrum and both dwarf galaxies (containing less than about three billion solar masses), sharing similarities with intermediate-mass black hole (IMBH, 100 to 100,000 solar masses) candidates. To further our understanding of the role of PRSs in the lifecycle of FRBs, and potentially black hole growth, it is crucial to discover more of them.

The Solution

To search for PRSs and IMBH, our team developed the matchmaker framework. Matchmaker is designed as an intuitive way to cross-investigate information from various astronomical catalogues. The framework is open-source and written in the Python language, making it simple to extend and use along other community-based packages. In particular, we make use of available Virtual Observatory packages where possible. The use of Python also makes matchmaker easy to port to various computing facilities, like those provided on EOSC Marketplace (e.g. Notebook servers). With minimal effort, one can start matching information between catalogues and rapidly investigate scientific questions. For our purpose, we searched the millions of radio sources contained in the second data release LOFAR Two-Meter Sky Survey (LoTSS) against other catalogues at different wavelengths (mid-infrared, optical, ultraviolet, X-ray, and gamma rays) and identified about 30 PRS/IMBH candidates.

The Research Community

The FRB community has been steadily growing since 2007, having a major annual conference, along with regular meetings and workshops. The field now covers various aspects ranging from theoretical modelling of likely progenitors and their emission mechanisms; observational methods, radio telescopes design, and algorithmic advancements; studies of host environments to FRBs; multi-wavelength and multi-messenger studies; and using FRBs as probes of the interstellar medium, circum-galactic medium, and potentially to cosmology.

Why do I need EOSC?

EOSC provides an ecosystem of data, software and publications. For instance, EOSC marketplace simplifies the entry-point for both researchers and students wanting to perform analyses on computing facilities. Within a few clicks, researchers can gain access to top-of-the-line compute and data, investigate research questions, or even reproduce scientific results. EOSC acts as a catalyst, enabling researchers at various career levels (from students to professors) to perform decentralized research.

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EOSC Future

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EOSC service or tool used

To achieve its goals, the project leveraged the capabilities of the European Open Science Cloud (EOSC), particularly utilizing the EOSC marketplace as a centralized platform.

This platform serves as a one-stop-shop that provides the means to discover and share a wide range of resources, including software, services, data sets, and publications.

Through the marketplace, we could access computing services, initiating data exploration and analysis. Logging in with AAI credentials provides access to a wealth of computing resources and datasets, making it possible to analyze and process data efficiently.

One of the key EOSC services used in the project was the EDI Notebooks service. From within marketplace, upon selecting the EDI Notebooks service, we could request the appropriate bundle for a given task, such as the "EDI Notebooks + B2Drop", which provided access to both computing resources and storage capabilities.

The seamless integration of these services within the EOSC framework allowed us to streamline the workflow and focus on scientific endeavors.

Benefits and impact

The benefits and impact of the project were various. Firstly, FAIRness of astronomical data and EOSC services empowered us to gain a deeper understanding of the potential population of luminous compact radio sources.
The synergy between data access, compute resources and human resources across EOSC facilitated comprehensive analyses, leading to insights that were not easily attainable otherwise, and sharing of method and results for better reproducibility.
Furthermore, the EOSC Portal and Marketplace provided a place to showcase our research and framework to a wider community and to engage with prospective users.

Useful material related to this story

matchmaker

Across disciplines

EOSC marketplace allows researchers from various scientific background to find datasets from other fields. While our software framework has been developed in the context of Astronomy and Astrophysics, the mechanisms it provides to deal with heterogenous datasets can serve researchers from other fields as well after minimal adjustment tailored for their science case.
Furthermore, cloud computing resources offered through EOSC can allow cross-disciplinary groups to form by accessing shared resources and storage. These research activity methodologies can serve as a platform to ease fluid collaborations.

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