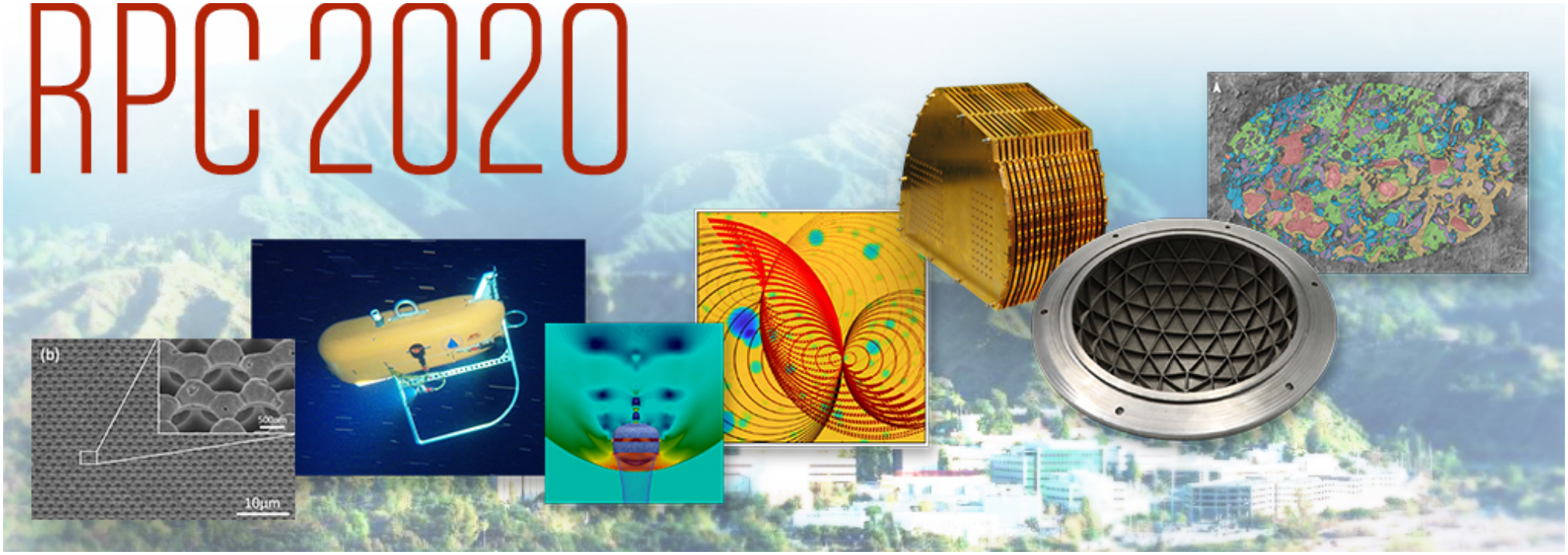


Virtual Research Presentation Conference

SEARCHING FOR NEUTRON STARS IN THE DENSE STELLAR CLUSTER AT THE CENTER OF THE GALAXY

Principal Investigator: Walid Majid (335D)
Co-Is: Thomas Prince (120, Caltech, PMA)
Program: Strategic

Jet Propulsion Laboratory
California Institute of Technology

Assigned Presentation # RPC-110

Tutorial Introduction

Abstract

The astrophysics of the dense star clusters in the vicinity of the central black holes of galaxies is a topic of great interest in astrophysics

Our own Galactic Center (GC) contains the closest massive black hole and is the only nuclear star cluster than we can study in detail

Millisecond pulsars (MSPs) have exquisite timing stability and are considered to be precision cosmic clocks

Finding one in orbit about the Galactic Center black hole would be a signature discovery

The DSS-43 antenna of the DSN offers one of the best capabilities of any telescope for high-frequency detections of MSP in the GC

The GC harbors a radio loud magnetar, a rare class of neutron stars, offering a window into the magneto-ionic environment of dense stellar clusters

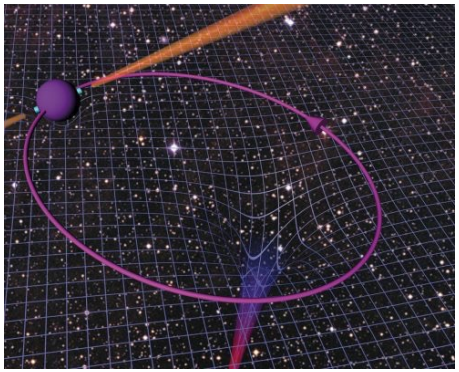


Image Credit: BlackHoleCam

Problem Description

a) K-band Pulsar Survey of the GC
- Multipath scattering in the interstellar medium broadens pulses with sharp frequency dependence
- We have built a state-of-the-art pulsar backend that operates at K-band (17-27 GHz) in Canberra
- DSS-43 is the most sensitive single dish radio telescope in the southern hemisphere
- We are carrying out a survey of the inner few arcminutes around the GC region
- Obtained 75+ hours, primarily comprised of pointings at the GC, but also surrounding region

b) High Frequency Observation of Magnetars
- Magnetars are a rare class of neutron stars with very high magnetic fields, providing the main engine for intense high energy outbursts
- Magnetars have flat radio spectra and are best studied at high radio frequencies, where the effects of interstellar medium is greatly reduced
- We are carrying out observations of active magnetars subsequent to high energy outbursts

c) Novel Detection Algorithms
- Searching for pulsars in binary systems with orbital periods longer than the duration of observations has been a computationally prohibitive task due to the large phase space, consisting of Keplerian parameters
- We are working on developing novel coherent search techniques that are capable of carrying out pulsar searches with higher derivative terms
- We plan to test and validate coherent search techniques by searching for pulsars in globular clusters, where a large number of MSPs have been identified

Results

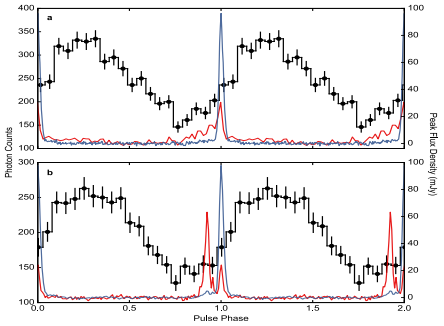
Multi-frequency Observation of Magnetars

- Detailed study of single pulses from XTE J1810-197 in both radio and X-ray
- Post-outburst studies of the new member of the radio magnetar class, Swift J1818

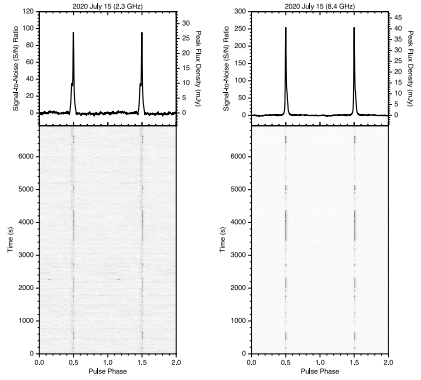
Carried out K-band survey of the GC using DSS-43 before long downtime

Develop and test new coherent search algorithm

- Obtained 100-hr archival GBT data on Terzan 5
- Completed cleaning of data
- Currently validating the search pipeline by identifying known pulsars



Pearlman et al. 2020



Bansal et al. 2020 (in prep)

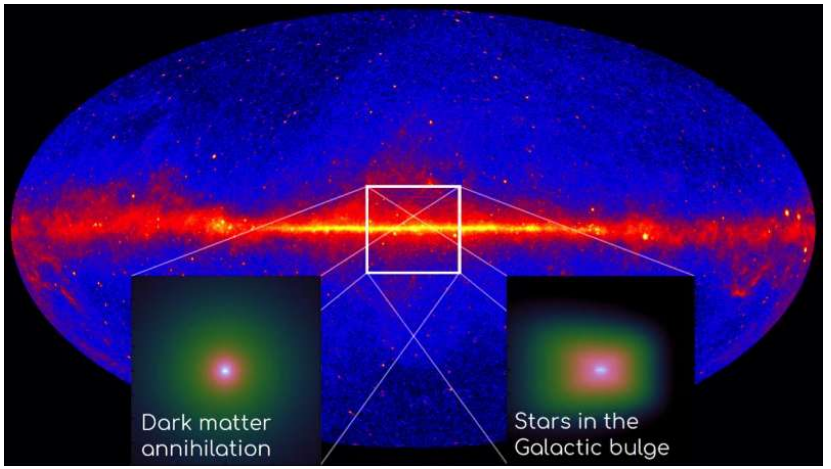
Significance and Next Steps

Significance

- This proposal is relevant to the goals and priorities of both 7X and 9X
- Carrying out research for which the DSN has unique capabilities
- Astrophysics of compact objects in nuclear star clusters
- Also relevant to current (NuSTAR, NICER, FERMI) and future (LISA) science missions

Next steps

- Complete the high frequency GC survey for pulsars
- Test and validate novel coherent algorithm for detection of pulsars in compact orbits



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[F] Bansal, K., Pearlman, A. B., Majid, W. A., Prince, T. A., et al., “Simultaneous Radio and X-ray Observations of Radio Magnetar J1818-1607”, in prep (2020).