ABSTRACT

The merger of a binary neutron star pair is expected to generate a strong transient radio signal. This emission will be strongest at low-frequency and will disperse as it transverses the interstellar medium arriving at Earth after coincidentally emitted gravitational or (higher frequency) electromagnetic signals. The rate of compact object merger events is poorly constrained by observations. The eight-meter-wavelength Transient Array (ETA) telescope is a low-frequency radio telescope initially located at the Pisgah Astronomical Research Institute (PARI), which is sensitive to a frequency range of 29-47 MHz. It is being upgrades and relocated to western Virginia where it will continue to conduct low frequency observations. This instrument is an all-sky instrument designed to detect astronomical sources of radio transients. We calculated the sensitivity of ETA to transient radio emission from binary neutron star mergers and used ETA observations to constrain the rate of such merger events to $< 1.3x10^{-2} \text{ Mpc}^{-3} \text{yr}^{-1}$.

RADIO TRANSIENT EMISSIONS

There are two forms of transient radio emissions that can be produced during binary neutron star mergers:

1. Emissions due to the acceleration of charged particles along the magnetic field lines of the merging objects – Compact Object Mergers

2. Emissions due to the merging of two highly dense stellar objects – Compact Object Mergers

Both mechanisms have a great deal in common with the standard pulsar emission process. However, in the second case the conversion of orbital energy can increase the ambient magnetic field strength by an order of magnitude, $B_{\text{merger}}=10^4 B_{\text{orbital}}$. This allows for a substantial increase in the potential detection of such a radio signature.

ETA

The eight-meter-wavelength Transient Array (ETA) is a radio telescope that is sensitive to a frequency range of 29-47 MHz. This instrument is composed of 36 dual-polarization dipole antennas and is an all-sky instrument. During its first science run ETA was located in western North Carolina at the Pisgah Astronomical Research Institute (PARI). The instrument is currently being upgraded and relocated to western Virginia.

In order to determine ETA's ability to detect radio emission from compact object mergers the signal strength of the radio transient emitted by the binary merger must be calculated and dispersion and scattering of the signal due to the interstellar medium needs to be taken into account.

Dispersions & Scattering

Dispersions occurs as radiation of different frequencies travels at different velocities through a medium. This causes astronomical radio signals which were emitted simultaneously to be observed as a spread-out in time or dispersed.

Calculating Sensitivity

Using results derived in [3, 4] we were able to calculate the sensitivity of ETA to radio transient emission from compact object mergers. This calculation involves taking a ratio between the observed signal strength at a given distance and the background noise primarily provided by our own galaxy, the Milky Way. In calculating the signal strength scatter broadening was accounted for unlike dispersion which can be removed during data reduction. The parameter $y$ encodes how much orbital energy is converted to the strengthening of the magnetic field which is $[1/2 y < 0]$.

RATE LIMIT ON NEUTRON STAR MERGERS

By using ETA observations we were able to set a bound on the rate of compact object merger events. Taking $y=5$ as a benchmark for a positive detection we were able to constrain the event rate of compact object mergers to be $< 1.3x10^{-2} \text{ Mpc}^{-3} \text{yr}^{-1}$. While this event rate is far higher than the expected theoretical rate of $8x10^{-8} \text{ Mpc}^{-3} \text{yr}^{-1}$ it represents one of the strongest current observational bound on such events. For comparison LIGO has set a bound of $2x10^{-4} \text{ Mpc}^{-3} \text{yr}^{-1}$.

REFERENCES


