



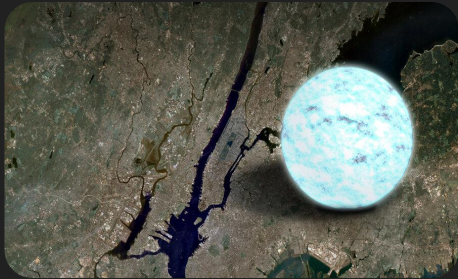
Searches for Gravitational Waves from Known Pulsars in the Second and Third LIGO-Virgo Observing Runs

Amy Hewitt on behalf of the LVK
Full paper at <https://arxiv.org/abs/2111.13106>

Pulsars (Neutron Stars)



Dense stellar remnants
of stars over $8 M_{\odot}$



Credit: NASA's Goddard Space Flight Center

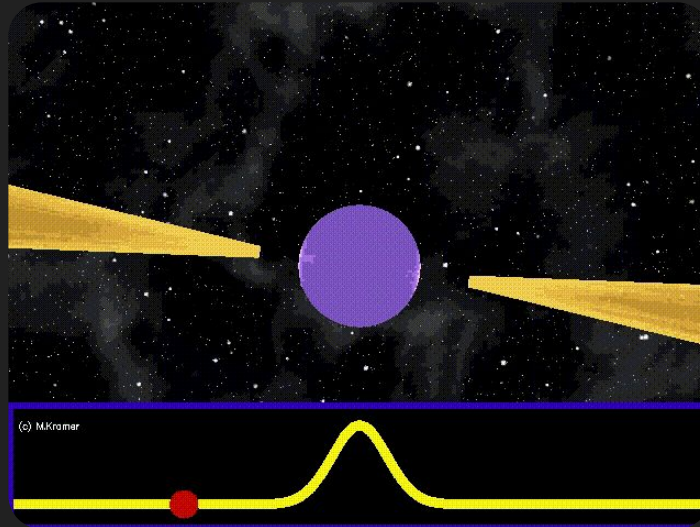


Image credit: Michael Kramer (JBCA, University of Manchester).

Periods can reach over
100 rotations per second
(Millisecond pulsars)

Emit powerful beams of
EM radiation from the
poles

Pulsars are neutron stars
with beams facing Earth

Difficult to observe
more than period and
distance estimates

The core of these objects
is still a mystery

Unknown equation of state

Gravitational Waves from Pulsars



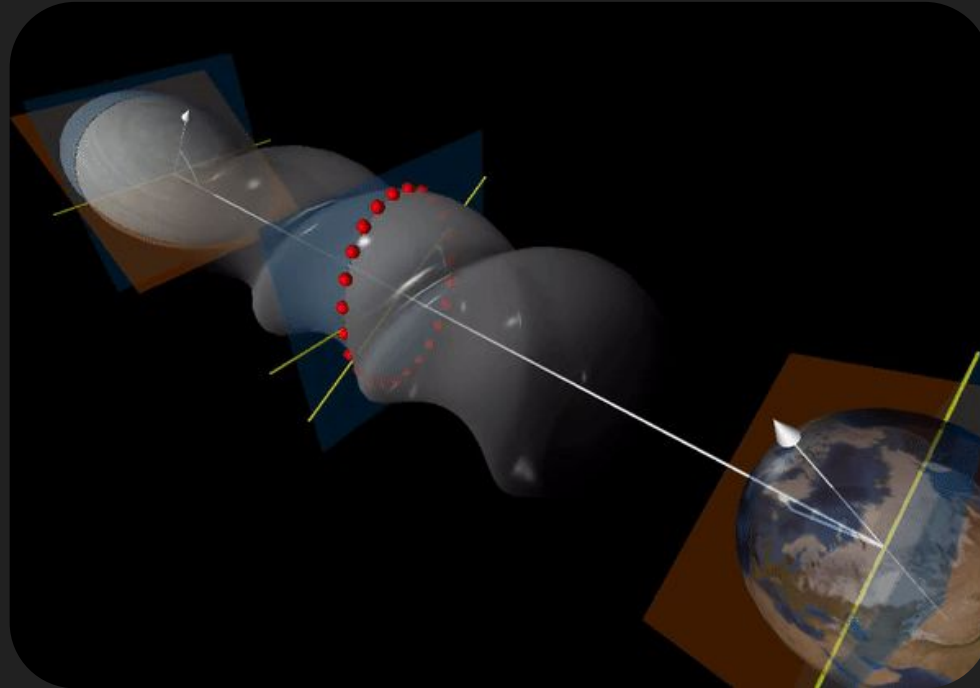
cm tall!
Mountains =
asymmetry about
rotational axis

Emission of
gravitational waves

Loss of angular
momentum

(Spin-down)

Measuring spin-down gives amplitude
estimate



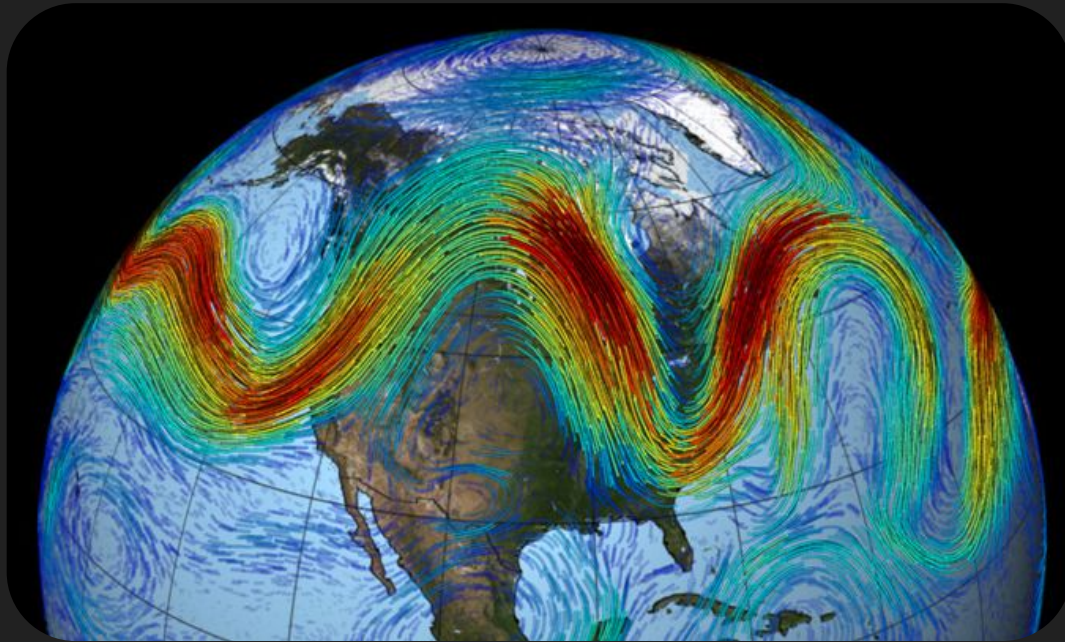
Credit: Graham Woan

Amplitude of GW
scales with f_{rot}

Within detector
sensitivity

Frequency of GW tied to
 f_{rot} such that $f_{\text{GW}} = 2f_{\text{rot}}$

Sometimes $f_{\text{GW}} = f_{\text{rot}}$
(Free precession,
rotating core, etc)



Credit: NASA/GSFC

Hypothesised processes
beneath crust emit GWs



R-waves occur on Earth,
predicted on pulsars



Evidence of processes



Various theories but
unknown EOS



EOS gives upper limits on
ellipticity

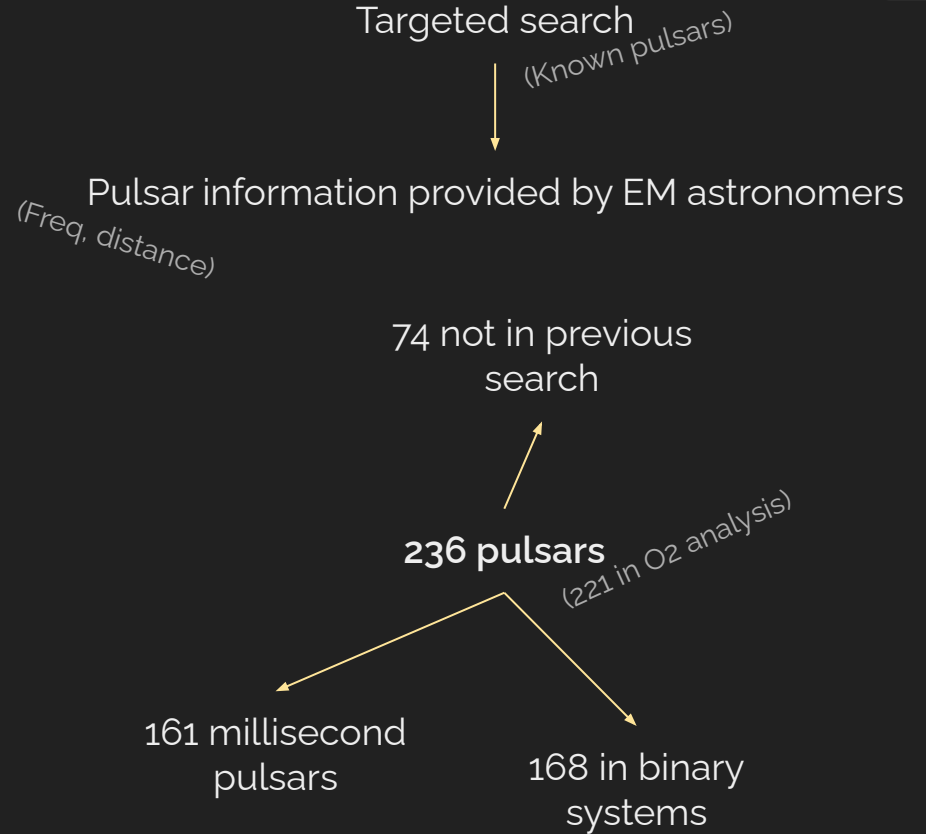


Observed ellipticities
constrain EOS

The Pulsars

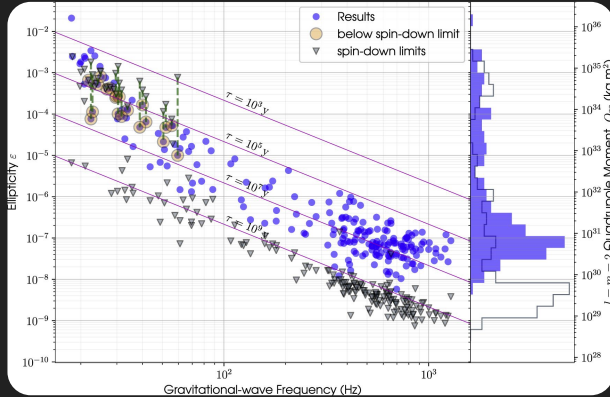


Credit: Getty Images



Previous search

<https://arxiv.org/abs/1902.08507>



O1 + O2 data

Time-domain Bayesian analysis

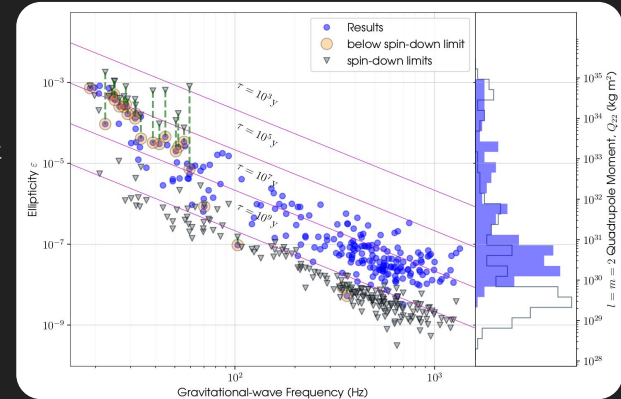
Dual harmonic search at f_{rot} and $2f_{\text{rot}}$
 Single harmonic search at $2f_{\text{rot}}$

F-/G-statistic and 5n-vector analysis on sources of interest

No GW detected, so 95% upper limits given

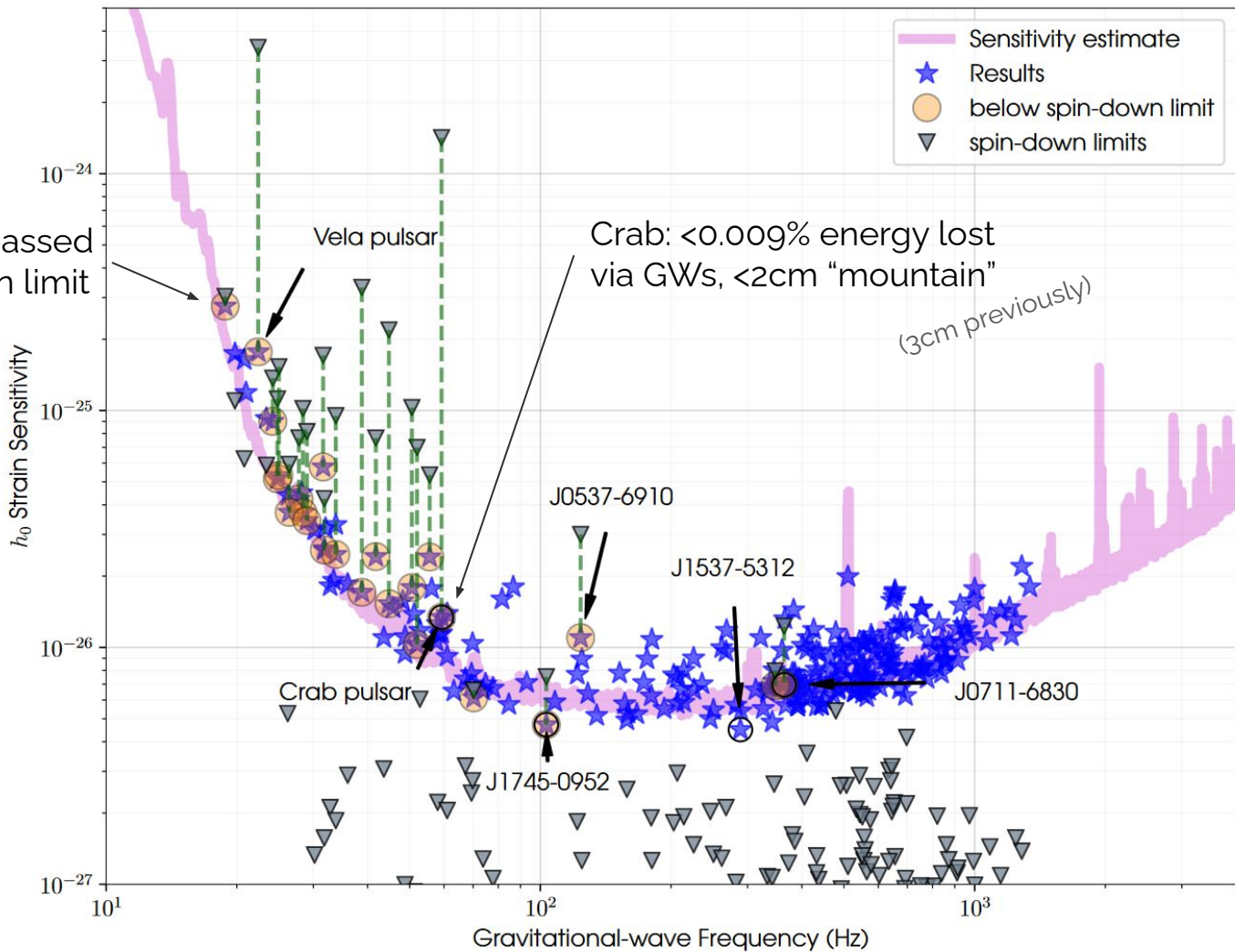
This search

<https://arxiv.org/abs/2111.13106>



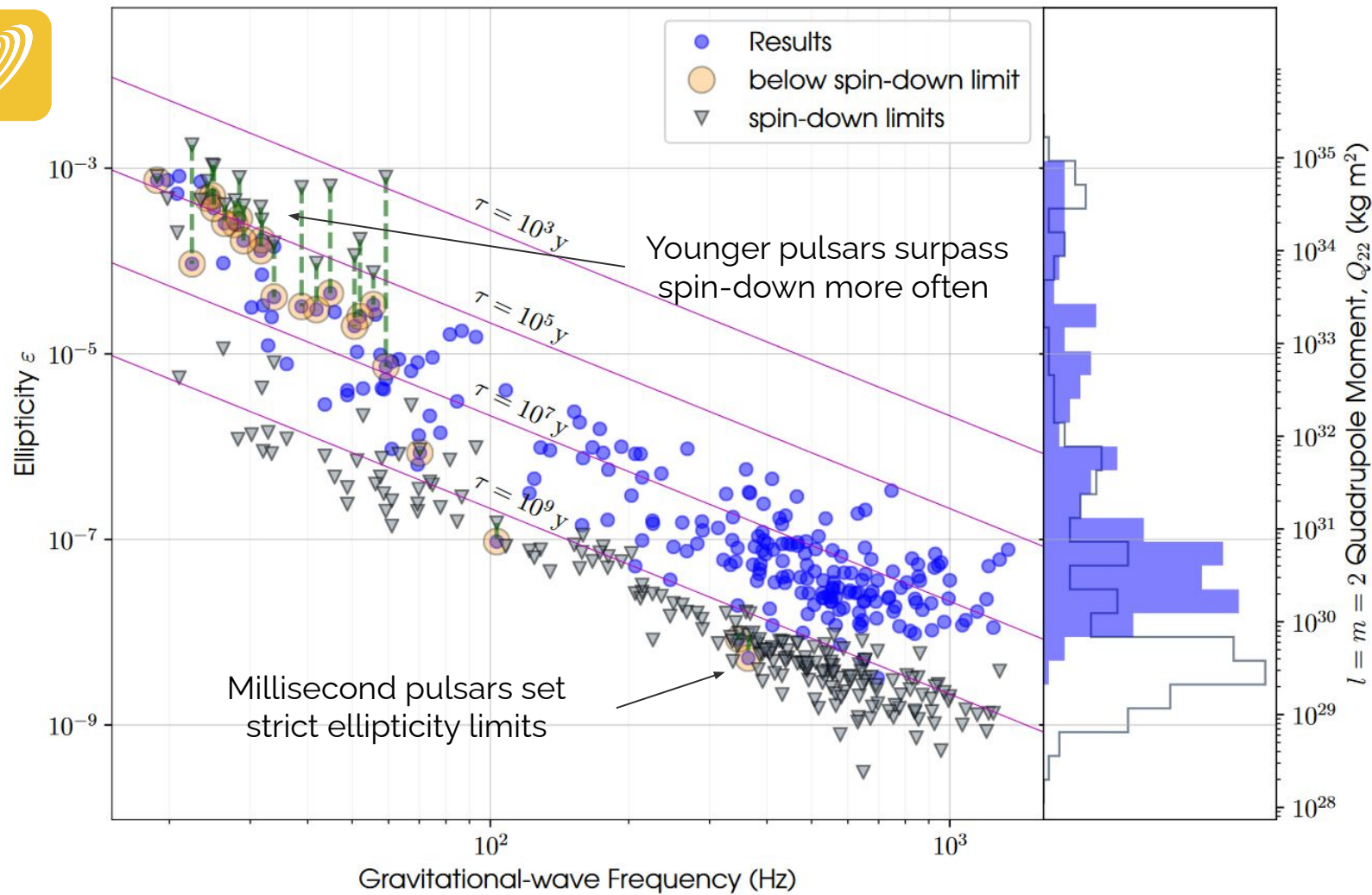
O2 + O3 data

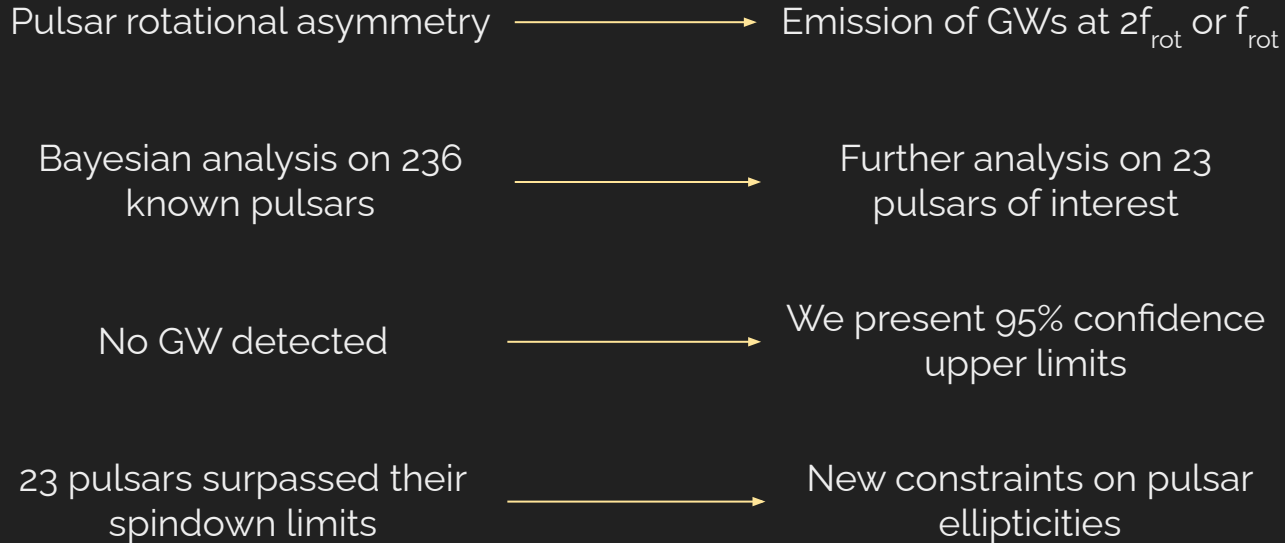
D-statistic analysis
 (Brans Dicke)



23 pulsars surpassed their spin-down limit

Crab: <0.009% energy lost via GWs, <2cm "mountain" (3cm previously)





Thanks for listening!