Echoes from the Abyss: A highly spinning black hole remnant for the binary neutron star merger GW170817

Jahed Abedi∗
Department of Physics, Sharif University of Technology, P.O. Box 11155-9161, Tehran, Iran and
School of Particles and Accelerators,
Institute for Research in Fundamental Sciences (IPM)
P.O. Box 19395-5531, Tehran, Iran

Niayesh Afshordi†
Perimeter Institute for Theoretical Physics, 31 Caroline St. N., Waterloo, ON, N2L 2Y5, Canada and
Department of Physics and Astronomy, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

The first direct observation of a binary neutron star (BNS) merger was a watershed moment in multi-messenger astronomy. However, gravitational waves from GW170817 have only been observed prior to the BNS merger, but electromagnetic observations all follow the merger event. While post-merger gravitational wave signal in general relativity is too faint (given current detector sensitivities), here we present the first tentative detection of post-merger gravitational wave “echoes” from a highly spinning “black hole” remnant. The echoes may be expected in different models of quantum black holes that replace event horizons by exotic Planck-scale structure and tentative evidence for them has been found in binary black hole merger events. The fact that the echo frequency is suppressed by \( \log M \) (in Planck units) puts it squarely in the LIGO sensitivity window, allowing us to build an optimal model-agnostic search strategy via cross-correlating the two detectors in frequency/time. We find a tentative detection of echoes at \( f_{\text{echo}} \approx 72 \text{ Hz} \), around 1.0 sec after the BNS merger, consistent with a 2.6–2.7 \( M_\odot \) “black hole” remnant with dimensionless spin \( 0.84 - 0.87 \). Accounting for all the “look-elsewhere” effects, we find a significance of 4.2σ, or a false alarm probability of \( 1.6 \times 10^{-5} \), i.e. a similar cross-correlation within the expected frequency/time window after the merger cannot be found more than 4 times in 3 days. If confirmed, this finding will have significant consequences for both physics of quantum black holes and astrophysics of binary neutron star mergers.


∗ jahed_abedi@physics.sharif.ir
† nafshordi@pitp.ca

[23] K. Hotokezaka, K. Kiuchi, K. Kyutoku, T. Mu-