again, unfortunately during the daytime, and in the evening, the Moon will appear 7° from them, showing a disk in the 6% phase. To conclude the month, the Silver Globe in the 13% phase will pass 5° north of Jupiter.

As always in the second half of the month, the Lyrids will radiate, with their peak activity around April 22. The radiant of the shower is located about 8° south-west of Vega and rises at dusk to reach a height of nearly 70° by the end of the astronomical night. At the peak, about 20 events per hour can be expected, and the Moon will not interfere with observations.

Ariel MAJCHER

Straight from Heaven: Again, That Mass Gap

We return to the issue of the 'mass gap,' referring to the hypothetical gap (or void) in the mass distribution of neutron stars and black holes, roughly 3 and 5 $M_\odot$ mass gap between the most massive neutron stars and the least massive black holes. We last wrote about it in Δ^9_{24}, and this time it reappears due to the publication by the LIGO-Virgo-KAGRA (LVK) team. The detection of the interesting GW230529 signal occurred on May 29, 2023, at the beginning of the ongoing LVK O4 observational run (spring 2023 – fall 2025).

During the first three observational campaigns (O1, O2, and O3), the LIGO-Virgo collaboration registered a total of 90 confirmed gravitational wave signals, but since the start of the O4 campaign, over 200 new signals have already been registered, mostly from the binary black hole systems. This is due, of course, to the improved sensitivity of the detectors and, consequently, the larger volume of the Universe from which signals are reaching us can be observed.

The GW230529 signal is particularly interesting because of its source – a binary system – consisted of an object with a mass typical for neutron stars, $1{,}4^{+0,6}-0,2, M\odot$, and a second object with a mass of $3{,}6^{+0,8}-1,2, M\odot$, located in the 'mass gap'. Signals from binary systems containing a component in the 'mass gap' have been previously detected by the LIGO and Virgo detectors, but this is the first for which the more massive component lies within it. Due to the fact that at the time of detection, only the LIGO Livingston detector (called L1) was operational, the exact position of the signal on the sky could not be determined. Unfortunately, the second LIGO detector (Hanford, H1) was in the process of being activated, and the Virgo detector (V) was completely offline at the time. As a result, the potential electromagnetic radiation that might have accompanied the final moments of GW230529 could not be observed. Astrophysical models predict the formation of a so-called kilonova, i.e., an explosion of hot radioactive matter after the binary system components collide, or the tidal disruption of a neutron star by a black hole before the final collapse.

LIGO and Virgo interferometers use triangulation to determine the source's position on the sky. This requires simultaneous detection by at least two, and ideally three, different detectors to compare time differences in the arrival of the gravitational wave and amplitude and phase differences in the signal at each detector. If only one detector is operational, only the arrival time of the signal can be measured, and the amplitude h of the signal can be estimated, i.e., the distance r to the event, because $h \propto 1/r$.

The detection of GW230529 is important for many reasons. First, it provides further evidence for the existence of compact objects in the 'mass gap,' an area previously considered to be sparsely 'inhabited.' The question remains, however, about the nature of the more massive component: it is presumably a low-mass black hole, but it is not excluded that it is a very massive neutron star (which would be an extraordinary discovery for researchers studying extremely dense matter). From the analysis of the wave that reached the L1 detector, it appears that the more massive component had a non-negligible spin χ (dimensionless angular momentum $\chi = cJ/(GM^2)$, where J is the angular momentum) estimated at $\chi = 0{,}44^{+0,40}_{-0,37}$. However, it is not as large as would be expected in the case of a black hole formed from the earlier merger of two smaller black holes. It is estimated that the merger of two smaller, non-rotating black holes leads to the formation of a black hole with a spin $\chi \approx 0{,}7$, which comes from the transfer of orbital angular momentum of the system to the final spin of the object.

This observation proves that earlier models of stellar evolution and black hole formation processes may need to be refined, as it is already apparent that black holes, especially light ones, can form in many ways, including through neutron star mergers, and perhaps also as a result of explosions of a special class of asymmetric supernovae. It seems more than certain that the 'mass gap' is not a real gap in the mass distribution, but rather a reflection of the current observational limitations. The not entirely successful observation of GW230529 (the failure to detect the phenomenon in electromagnetic waves) is still significant for 'traditional' astrophysics, because now that we have detected GW230529, we will likely detect more events of this type in the future, potentially accompanied by the observation of the electromagnetic signals. These will provide information about the properties and behaviours of compact objects in this mass range.

A. G. Abac et al., "Observation of Gravitational Waves from the Coalescence of a $2.5 - 4.5, M_\odot$ Compact Object and a Neutron Star", 2024, ApJL 970 L34.

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