https://doi.org/10.1038/s41550-023-02170-y

The black hole revolution needs you!

By C. M. F. Mingarelli

The NANOGrav collaboration has found light-years long gravitational waves from, most likely, the mergers of millions of supermassive black holes. To keep watching this cosmic dance, we need sustained funding for black hole research.

The Nobel Prize for Physics was recently awarded for the generation of attosecond pulses of light. As an expert on black holes, I would have loved to see someone from my field awarded, but black hole research has already won the Nobel Prize for Physics twice in the past seven years. In fact, we are living through a black hole revolution, which started with a bang in 2015.

This bang came from two merging black holes, each one 30 times the mass of the Sun. The bang was found by a gravitational wave (GW) detector called LIGO. Before the LIGO detection, almost 40 years of searching yielded no GWs. Now, LIGO and its Italian counterpart, Virgo, have 90 confirmed GW detections.

LIGO, however, is not the only GW detector. Last summer, the experiment I've been working on for the past decade, called NANOGrav, announced evidence for a GW background, which likely comes from the cosmic hum of simultaneous supermassive black hole mergers. Our international partners in Europe, India, Australia and China also found evidence for this background. Our current models estimate that this cosmic background hum is likely generated by millions of slowly merging supermassive black holes, each pair hundreds of millions to billions of times the mass of the Sun. Before finding this background, we didn't know if supermassive black holes merged at all. Now there is potentially evidence for millions of merging pairs.

Even though these GWs are millions of times stronger than those found by LIGO, LIGO could not have detected them. Just as we need different telescopes to observe different wavelengths of light, so too do we need different GW 'telescopes' to observe the whole spectrum of GWs.

It took NANOGrav 15 years to find the first nanohertz GW signal. We did this by turning our Galaxy into a GW detector — monitoring ultra-stable pulsars. Pulsars are cosmic lighthouses, sending out flashes of radio waves with every spin. These flashes are so steady that you can literally set your watch to them, making them nature's GW detectors. The light-years-long GWs ripple through our Galaxy, slowly changing the distance between the Earth and the pulsars, which results in pulsar pulses arriving a little early or a little late. And by a little, I mean about 100 nanoseconds over a decade.

While GWs are difficult to detect, the supermassive black holes that are merging in galaxies far, far away could put on some spectacular fireworks. That's why I am also thrilled that this new era of black hole discovery is coinciding with the age of giant telescopes. Complementary data from telescopes and GW detectors will be transformational. We will test Einstein's theory of gravity in the strongest gravitational regimes possible — around supermassive black holes — and take pictures of the galaxies hosting them. We will finally discover what's around these giant black holes: gas? Dust? Stars? Nothing? We should also be able to know whether these supermassive black holes launch immense jets or are quietly merging.

So, what's next? We will be making more maps of the GW background, looking for hotspots. I am thrilled by the prospect of looking at a GW hotspot's position on the sky through a telescope and seeing nothing at all. It could mean that the black holes there have no gas or stars around them, or that something other than black holes is creating the GWs.

At the same time, I am once again completing my yearly ritual of grant writing to support this research. While grant writing takes a huge amount of time, I can't help but feel that I owe it to my 12-year-old self, who dreamed about black holes and exploring outer space, to spread the good word: the black hole revolution is here! We should all be excited that we can now measure space-time ripples that are up to light-years long.

Now is the time to invest in black holes. We are only scratching the surface of what we can learn about the Universe through GWs. To keep up the momentum, we need sustained investments from private and public sectors. I am sure that I am not alone in daydreaming about how many more discoveries we could make if only funding were less scarce. It is true that black hole research is unlikely to solve world hunger and may be difficult to relate to anything in our everyday experience, but it will give us valuable insights into the nature of space and time, while addressing existential questions about the nature of the Universe and our place in it.

For now, I am exhilarated by all the new discoveries about black holes and GWs that are part of this black hole revolution: a GW background, GWs from merging neutron stars and black holes, with hundreds more anticipated over the next few years. There will almost certainly be many Nobel Prize-worthy discoveries by the end of the decade. The progress in black hole research promises to deepen our comprehension of the Universe and facilitate groundbreaking insights, but sustained support is critical to realize these discoveries and dreams.

C. M. F. Mingarelli [1,2]
[1]Department of Physics, Yale University, New Haven, CT, USA. [2]Public Voices Fellow, OpEd Project.
e-mail: chiara.mingarelli@yale.edu

Published online: 14 December 2023

Competing interests
The author declares no competing interests.

CREDIT: CHIARA M. F. MINGARELLI