

» INTERVIEW**LET ME TELL YOU HOW VIRGO WAS BORN**

Interview (February 2016) with Adalberto Giazotto, recently passed away, founder of the Virgo project for gravitational waves detection.

His name is firmly tied to the physics of gravitational waves, the spacetime ripples predicted by Albert Einstein a century ago in the theory of General Relativity. Adalberto Giazotto, an INFN researcher who passed away last 15 November, a tenacious, visionary and far-sighted scientist, former collaborator of Edoardo Amaldi, shared with Alain Brillet the paternity of the Virgo interferometer, the gravitational wave detector implemented in Italy by INFN and the French CNRS (Center National de la Recherche Scientifique) which, with the two LIGO interferometers in the United States, was the protagonist of the recent discovery of gravitational waves. It was Giazotto's idea to build an interferometer in the countryside around Pisa. He had the idea of the Virgo super-attenuators, a chain of highly technological pendulums that effectively isolates the mirrors of the experiment from the movements that would disturb the signals. It was his idea to look for gravitational waves at low frequencies - where they were actually found - an idea first implemented by Virgo and later by LIGO. It was his idea to establish a global network of interferometers with the two LIGOs, so as to create only one big scientific collaboration, an idea that proved to be key to the success in searching for gravitational waves.

In an interview released in February 2016, Giazotto told us how the idea of Virgo came about and what were his feelings when he heard the news of the discovery of gravitational waves, the goal he had pursued for decades.

How are you feeling during these days of the announcement of the discovery of gravitational waves?

Very happy, even though I am a bit of a spectator. I am very happy with this result, which represents the crowning of a line of research that we at Virgo started decades ago, focusing on low frequencies.

» INTERVIEW

You are considered the father of Virgo.

We were the first to say that it was necessary to build a detector capable of observing gravitational waves also at low frequencies. It was the biggest advancement in interferometer technology since these detectors were started to be built in the 1980s. Virgo, finally approved in 1993, was in fact the world's first low-frequency detector, followed by the American Advanced LIGO (Laser Interferometer Gravitational-wave Observatory) project and the KAGRA (Kamioka Gravitational wave detector), project, under implementation in Japan.

What were the reasons for this choice?

The low-frequency target was dictated by theoretical studies on the structure of neutron star binary systems and black holes as extremely powerful gravitational wave emitters. Moreover, the radio-astronomical signals of pulsars - rotating neutron stars - showed the existence of a relatively large number of stars, capable of emitting periodic gravitational waves at frequencies greater than 10 Hz. At that time, the minimum frequency of gravitational wave signals detected by existing antennas was approx. 100 Hz and, therefore, much higher than that needed to capture astrophysical phenomena such as those described above.

How did the idea of Virgo come about?

It came thanks to a stroll with Alain Brillet, from CNRS, around the Minerva fountain in the courtyards of La Sapienza University in Rome. It was the early 1980s and the Roman university was hosting a congress on General Relativity. It was on that occasion that, along with the French colleague, we decided to start a collaboration for the construction of Virgo. But the interferometer would never have come about without IRAS (Interferometer for Active Sisma Reduction), which can be considered one of Virgo's ancestors. In fact, in 1987 we demonstrated that it was possible to mitigate seismic noise, which prevented going down to low frequencies and, also due to this result, Italy approved the Virgo experiment.

The gravitational waves observed by the LIGO/Virgo collaboration were generated by the fusion of two black holes: did that surprise you?

No, I was not surprised that this was the source. Thinking years ago about implementing Virgo, I had chosen to focus on the periodic signals of pulsars and on those, almost periodic, emitted by the systems of coalescing binary neutron stars and black holes. All this in order to have a signal that lasts for at least a few seconds, and not a few milliseconds like those emitted by supernovae explosions. Pulsars, from this point of view, would have been ideal, whose signal is strictly periodic and lasts forever over time. Unfortunately, all the pulsars we tried to observe did not give us any signals. Nature could have made

» INTERVIEW

us a small gift, letting us see gravitational waves several years earlier. But it was not to be. Einstein had predicted their existence about a century ago.

Why did it take so long for the first direct observation?

The reason is that these signals are extremely weak and it is therefore extremely difficult to capture them. Advanced Virgo will be able to measure, starting from the second half of 2016, changes in the length of the arms, due to the passage of a gravitational wave, a billion times smaller than the diameter of a hydrogen atom.

Do you think that the observation of gravitational waves will become more frequent from now on?

Yes, I do. In the end, the LIGO/Virgo collaboration saw two signals, one very shortly after the other. In the future, we may be able to see many more per year

Including the primordial signals emitted shortly after the Big Bang?

In this case, the observation is much more difficult. But if we were able to capture primordial gravitational waves, it would be a very important result. These signals are, in fact, the only ones that can directly tell us how the universe appeared in its first moments of life, in proximity to the so-called Planck's time (10-43 sec. after the Big Bang) but they are extremely small in intensity compared to those we can now see with Virgo and LIGO. ■