Novel tools to analyse radiation near black holes

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With the current state of scientific knowledge and equipment, understanding astrophysical black holes invariably requires detailed studies of the observable elements surrounding them. The STRONGGRAVITY project has developed novel analytical tools to do just that, with a focus on radiation.

Radiation processes taking place near black holes tell us much about physics in extreme conditions, conditions that not even the most advanced experimental setups can recreate. They also provide a unique opportunity to test Einstein's theory of relativity in the strong-field regime.

Using data from the European Space Agency's XMM-Newton X-ray satellite mission, the European Southern Observatory and other relevant sources, the STRONGGRAVITY (Probing Strong Gravity by Black Holes Across the Range of Masses) project aims to better understand these radiation processes. Dr Michal Dovciak, along with his team at the Astronomical Institute of the Czech Academy of Sciences, has spent the past four years analysing and interpreting multi-wavelength spectral and fast timing observations of systems containing black holes in order to further this understanding.

The project's new tools, which can compute the spectral, timing and polarisation properties of radiations in the black hole vicinity, are hoped not only to contribute to astrophysics, but also to enable new research and scientific ideas in Europe and beyond.

Why is it important to better understand radiation processes near black holes?

Black holes are quite well understood as mathematical objects, however there are still many mysteries as to how they behave as astrophysical objects. How do they interact with their surroundings at the centre of galaxies? How do they feed on nearby matter and what is the nature of their accretion? What are the reasons for the outflows by which they feed the host galaxy?

All the information we can get on black holes as astrophysical objects originate from radiations in their close vicinity, especially those with very high energy. Therefore, we concentrate mainly on X-rays. We have to decipher all the processes that create or influence this radiation to better understand what is going on, more specifically, what components these systems consist of (accretion disc, corona, winds, etc.), what their properties are and how they mutually interact.

Which type of black holes do you focus on and why?

We focus on numerous bright, active galactic nuclei sources – each hosting a super-massive black hole of a mass range equivalent to millions or billions of solar masses – as well as a few black holes of stellar origin within our galaxy.

A particular source of interest is Sgr A* – the super-massive yet quiet black hole at the centre of our galaxy. We have concentrated on the most active species of black holes, since they provide us with the largest possible amount of information for studying them.

What would you say were the main contributions of the project?

We have developed some new sophisticated tools and models as well as enhanced pre-existing ones. These tools and models are now being used by astronomers to much better understand the data that come from ground-based and satellite observations.

Using those tools, we have for example detected the first-ever hint at the relativistic precession of the orbit of one of the stars that are closest to the Milky Way's central black hole.

How will these new tools contribute to future missions like ATHENA?

We have already used them for defining the scientific topic 'The close environments of the super-massive Black holes' for the mission ATHENA. We have simulated observations with different instruments of this mission to estimate their performance in different possible configurations. The two main objectives in this theme consist in measuring black hole rotation via X-ray reflection from the accretion disc as well as the geometry of accretion disc corona via X-ray reverberation studies.

How can your tools be accessed and used by the scientific community?

We have a dedicated web page on our website where the tools are provided together with documentation on how to use them.

What do you still need to achieve before the end of the project?

There are several subprojects that are yet to be completed and we would like to finalise them before the end of the project. We are still working on computations of the influence that the corona has on accretion disc emission, we are improving the code for X-ray reverberation studies and we would like to finish the reflection model for galactic black hole binaries.

More information: Project website: stronggravity.eu/

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