1. A Physical-Historical Overview

Black holes are part of everyday astronomy nowadays. But they are also still one of the greatest mysteries of the universe. The *gravitational force* emanating from them is so great that even light is swallowed up by them and can no longer escape.

Black holes are thus invisible (hence the name) and can be detected – if at all – only by indirect observation of radiating plasma rings or hurtling particle jets.

In 2019, the Event Horizon Telescope, a worldwide network of radio telescopes, enabled astronomers to take the first radio telescopic image of the extremely massive hole M87* at the centre of the galaxy M87, which has 6.6 billion solar masses.

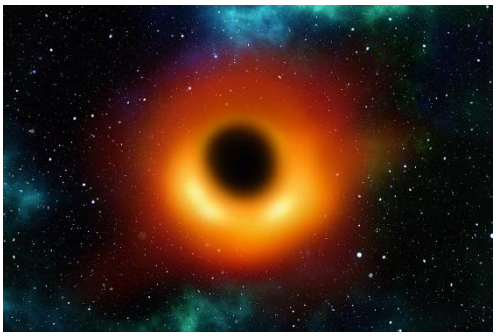

Fig. 1: Example image of a black hole
Source: https://pixabay.com/illustrations/black-hole-fake-abstract-photoshop-4118711/

However, many years of intensive research passed before it was possible to document black holes with impressive images. For more than 50 years, physicists have suspected that most large galaxies harbour a black hole – with millions to billions of solar masses – at their centre.

On the path between a galactic centre and our Earth are countless stars as well as huge clouds of interstellar gas and dust. This matter absorbs all visible light from the central regions of the Milky Way so that it is possible to catch a glimpse of selected objects only by using special methods. This is possible with the help of radio and infra red telescopes because these areas of the electromagnetic spectrum can penetrate the interstellar clouds.

Researchers led by Prof. Reinhard Genzel (*1952) from the Max Planck Institute for Extraterrestrial Physics in Garching and Prof. Andrea Ghez (*1965) from the University of California in Los Angeles have been making use of these technical possibilities since the early 1990s in order to study an object called Sagittarius A* in the centre of our galaxy – the Milky Way – 26,000 light years away.

Independently of each other, both research teams succeeded in measuring the motion of stars near the galactic centre over a period of almost two decades. Based on their results, they concluded the existence of a massive black hole of around four million solar masses.

The two researchers each received one quarter of the 2020 Nobel Prize in Physics for their work on the grounds that they had provided the most convincing evidence to date of a supermassive black hole at the centre of the Milky Way – according to the Royal Swedish Academy of Sciences.

The other half of the prize was awarded to the British mathematical physicist Prof. Roger Penrose (*1931) from Oxford University, whose theoretical derivations provided computational proof as early as the 1960s that black holes are just as natural a consequence of Albert Einstein's general theory of relativity from 1915 as, for example, curved light beams or the change in the passage of time under the influence of gravitational fields. This was certainly a special honour for Roger Penrose, because the Nobel Prize in Physics is awarded for theoretical work only if the theory has been confirmed by experiment or observation – which is exactly what the other two Laureates did.

2. Videos and Texts on Black Holes (in German and English)

1. In a highly informative lecture with numerous animations and illustrations on the occasion of the Lindau Online Matinee, Dr. Hannah Übler (PhD student in Prof. Reinhard Genzel's team) clearly explains the most important facts about black holes and the research of Reinhard Genzel and Andrea Ghez:

   https://www.mediatheque.lindau-nobel.org/videos/38866/2021-matinee#from=1h16s

2. Further explanatory material on the subject of black holes can be found under the following link:

   https://www.lindau-nobel.org/?q=schwarze+l%C3%B6cher&s=

3. The Video "Black Holes in a Nutshell" can be watched with either German or English subtitles:

   https://www.youtube.com/watch?v=yWO-cvGETRQ

4. Information Poster on Black Holes by NASA:

   https://fermi.sonoma.edu/teachers/blackholes/BFfactsheet09wide.pdf

3. Videos to Understand the General Theory of Relativity

1. Einstein's General Relativity explained via scrollytelling:

   https://vis.sciencemag.org/generalrelativity/

2. Albert Einstein's ingenious interpretation of gravity:

   https://www.einstein-online.info/en/category/elementary/general-relativity-elementary/

