gone even further, with an interest in the new discoveries of binary stars, speculating how one could infer the existence of these dark objects. He wrote:

... we could have no information from light; If any other luminous bodies would happen to revolve around them we might still perhaps from the motions of these revolving bodies infer the existence of the central ones with some degree of probability.

The observations made by the teams led by Reinhard Genzel and Andrea Ghez have allowed them to make precisely this inference, for which they are awarded this year's Nobel Prize in Physics. The theoretical work by Penrose in the other half of this year's Prize was essential for the study of black hole physics, and a great motivation for astronomers in their search for good candidates.

The Schwarzschild metric

On 13 January 1916, less than two months after Einstein completed his theory of general relativity on 18 November 1915, and less than four months before his own death, the German astronomer Karl Schwarzschild published a solution to Einstein's field equations, describing the curved space-time around a spherically symmetric, non-rotating, mass (Schwarzschild 1916). His metric takes the form

$$ds^2 = \left(1 - \frac{2GM}{c^2 r}\right) c^2 dt^2 - \frac{1}{1-\frac{2GM}{c^2 r}} dr^2 - r^2(d\theta^2 + \sin^2\theta\, d\phi^2).$$

For years to come, only the leading term in a large radius expansion of Schwarzschild's metric was of any practical use in tests of general relativity, such as the Mercury perihelion precession, light bending, or the Pound-Rebka experiment in 1960, confirming gravitational time dilation. Only recently has it become possible to test the metric beyond leading order, but it quickly became clear that the metric had two intriguing features at positions $r = 0$ and $r = \frac{2GM}{c^2}$, where some of its components diverged or vanished. What was their significance?

In the early 1920s, the French mathematician and politician Paul Painlevé (Painlevé 1921), and the Swedish optician Allvar Gullstrand[1] (Gullstrand 1921) independently found what they both believed to be a new and different solution to Einstein's equations. They each argued that their discovery rendered general relativity incomplete. In 1933 the Belgian priest and cosmologist George Lemaître proved that their metric was simply a coordinate transform of the one of Schwarzschild (Lemaître 1933). The confusion over how to interpret the metric persisted for years. Eventually, researchers determined that $r = 0$ corresponds to a true singularity, while the so-called Schwarzschild singularity at $r = R_S = \frac{2GM}{c^2}$ is just an artefact generated by the choice of coordinates. An observer can use local measurements to discern that something dramatic happens at $r = 0$ but not at $r = \frac{2GM}{c^2}$. Only much later, through the work of David Finkelstein in 1958, the importance of different coordinate systems was fully understood (Finkelstein 1958).

We now know that R_S has an important *global* significance as the point of no return, which we call the *event horizon*. Its position precisely coincides with the value proposed long ago by Michell and Laplace, based on Newtonian gravity and the assumption of a particle nature of light. Was it just serendipity that they had found the correct expression as early as the end of the 18th century? Not completely. In special relativity, time dilation in the form of a non-trivial Lorentz factor, gives rise to the relativistic expression for kinetic energy, while gravitational time dilation is associated with potential energy. To obtain the escape velocity, the energy of the test particle moving radially in the Schwarzschild background should be equated with the rest energy of the particle positioned far away from the gravitating mass.

[1] Gullstrand was a long-time member of the Nobel Committee for Physics, and the 1911 Laureate in Medicine or Physiology. Ironically, he argued *against* awarding the prize to Einstein for general relativity.