§ Kerr black hole

Roy Kerr 1934~

ASR398B black holes Fall 2015 Christopher Reynolds

1. Discovered exact solutions of Einstein's equations describing a spinning black hole。
2. Was later shown that this solution is unique…any spinning (uncharged) black hole is described by the Kerr solution。
3. No hair theorem：Any (isolated) black hole is described by just (1)mass (2)spin (3)electrical charge

Ergosphere：動圈 旋轉黑洞外面的區域。

The even horizon

Spacetime and Geometry p.261

We could go into a good deal more detail about the charged solutions, but let's instead move on to rotating black holes. To find the exact solution for the metric in this case is much more difficult, since we have given up on spherical symmetry. Instead we look for solutions with axial symmetry around the axis of rotation that are also stationary (a timelike Killing vector). Although the Schwarzschild and Reissner–Nordström solutions were discovered soon after general relativity was invented, the solution for a rotating black hole was found by Kerr only in 1963. His result, the **Kerr metric**, is given by the following mess:

$$\begin{aligned} ds^2 = &-\left(1-\frac{2GMr}{\rho^2}\right)dt^2 - \frac{2GMar\sin^2\theta}{\rho^2}(dt\,d\phi + d\phi\,dt) \\ &+ \frac{\rho^2}{\Delta}dr^2 + \rho^2 d\theta^2 + \frac{\sin^2\theta}{\rho^2}\left[(r^2+a^2)^2 - a^2\Delta\sin^2\theta\right]d\phi^2, \end{aligned} \tag{6.70}$$

where

$$\Delta(r) = r^2 - 2GMr + a^2 \tag{6.71}$$

and

$$\rho^2(r,\theta) = r^2 + a^2\cos^2\theta. \tag{6.72}$$

The Kerr spacetime：A brief introduction Matt Visser

The Kerr spacetime was discovered in 1963。