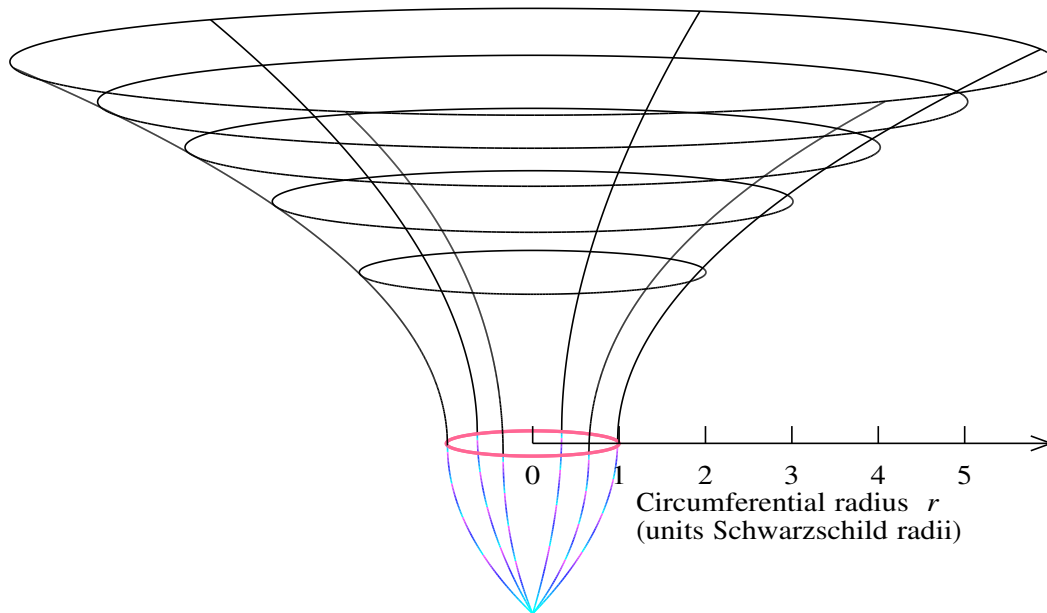


Embedding diagram of the Schwarzschild geometry

Schwarzschild's (1916) geometry describes the geometry of *empty* space surrounding a *spherical* mass. Schwarzschild constructed his geometry using coordinates adapted to observers at rest.

The embedding diagram below is a 2-dimensional representation of the 3-dimensional spatial geometry at a particular instant of Schwarzschild time. Each circle actually represents a sphere, of circumference $2\pi r$, as measured with a ruler by observers at rest in the geometry. According to the Schwarzschild metric, the proper radial distance measured by observers at rest is larger than the radial interval expected in a flat, Euclidean geometry. Thus the geometry is “stretched” in the radial direction, as shown in the embedding diagram.

The stretching is infinite at the horizon, so the geometry there looks like a vertical cliff. Einstein and his contemporaries were confused by the infinite stretching, which they called the “Schwarzschild singularity”. Nowadays we recognize that the “Schwarzschild singularity” is actually the horizon. The singularity is an artefact of the choice of coordinates: since space falls at the speed of light at the horizon, there is no such thing as an observer at rest there.



Outside the horizon, radial lines in Schwarzschild's geometry are “space-like”: an observer at rest measures radial intervals to be intervals of space. But inside the horizon, radial lines in Schwarzschild's geometry switch to being “time-like”: they represent intervals of time rather than space. This strange behavior simply confirmed Einstein's confusion. He thought that the horizon (as we now know it to be) was an impenetrable barrier. Nowadays we understand that the timelike radial interval means that space is falling faster than light inside the horizon. The radial direction is a direction in time: as an infaller's proper time proceeds, they necessarily fall to smaller radius. To remain at rest inside the horizon, an observer would have to move faster than light through space, which is impossible.