Karl’s Last Paper

Karl Schwarzschild died (of disease) on Germany’s Eastern Front on 1916 May 11. His epochal paper providing the ‘Schwarzschild solution’ to Einstein’s Field Equations of General Relativity had just been published (with Einstein’s assistance and enthusiastic approval).

I am pleased to say that before Karl died, he wrote a further brief paper, expanding on his discovery. Pun intended. I present his paper here, having stumbled on it, in a dream last night.

Implications of the Newly-Discovered Solution to the Field Equations of General Relativity

By Karl Schwarzschild

I have new thoughts on the astronomical implications of the solution to Einstein’s Field Equations that I have recently been able to provide. These thoughts may be useful in suggesting observational projects for astronomers. Recall my result, in natural units and ignoring rotation (it will surely be some time before a solution incorporating angular momentum will be found!):

$$h^2 = \frac{r^2}{\left(1 - \frac{2m}{r}\right)} - t^2 \left(1 - \frac{2m}{r}\right)$$

$m$ = the mass of a point object (smaller, even, than a white dwarf star), located at the origin of coordinates. (The sun’s $m$ is ~1 mile but the sun is much bigger : so my solution does not apply)

As observational astronomy progresses, maybe massive stars even more compact than white dwarfs will be found—possibly even stars for which my equation above actually does apply! Light could not escape—we would have to call them black holes. But even if black holes are not found, the demonstrated correctness of General Relativity (the observed precession of the orbit of the planet Mercury!) tells us that we would be wise to examine the above equation carefully, to see if it might contain further implications. And it seems to me that it does, for the case $m$ extremely small (or zero). In that case, my equation becomes simply

$$h^2 = r^2 - t^2$$

Since $h^2$ is invariant, the fact that time $t$ is observed universally to be passing (clock readings always increase—an observational fact!) says that we can deduce immediately that the separations $r$ of all points in the universe must be increasing linearly with time, or in other words: that the entire universe MUST necessarily be expanding.

My understanding is that so far, astronomers report no such expansion of the universe! But my conclusion here, is that that is true only because our Galaxy is a gravitationally-bound system. Space itself (in which our Galaxy is lodged) is surely expanding around it! As we look deeper into the universe, I hope we will find other galaxies similar to our own. They, too, will fail to expand, but their distance from us, I predict, will be found to increase linearly with time. This universal expansion will be slowed by (the average density of ) the matter in our universe. With future telescopes (possibly even telescopes orbiting the Earth) we will struggle to fully determine the geometrical structure of the universe...

I must go off to sleep now (as I seem to be feeling just a bit ill) .....  

-----------------------------

The Schwarzschild radius of Black Holes will increase by 7% / Gigayear

Richard Conn Henry