Cosmology 1

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Proposed problem, lectures 2 and 3
Topic: black holes.

After 20 years of travel (according to its own clock), the spaceship described in the Proposed Problem of lecture 1 arrives at the center of the Galaxy, where it meets a well-known black hole, called by astronomers SgrA*, whose mass is 4×10^6 M$_\odot$. With a suitable rocket system, it stops at a coordinate position $r_0 = 1000 R_s$, in a coordinate system at rest with the black hole for which the metric takes the Schwartzschild form. The spaceship then lets a probe free-fall toward the black hole.

(a) How (coordinate-)distant is the spaceship from the black hole in m? express it in Astronomical Units, AU $= 1.50 \times 10^{11}$ m, the average distance of the Earth from the Sun.

(b) Fix the values of the orbital parameters $\tilde{E}$ and $\tilde{L}$ in this case, and find the equations of motion for the probe.

(c) The spaceship receiver can detect signals from the probe with a tolerance of a factor 10 in frequency. Neglecting any Doppler contribution, at which coordinate distance is the signal lost? how large is the gravitational redshift at that point?