A Student's Manual for A First Course in GENERAL RELATIVITY

Errata

ROBERT B. SCOTT

8 The Einstein field equations

> [The Einstein Field Equations] Eq. (8.10) should be regarded as a system of ten coupled differential equations. . . . These ten, then, are not independent, and the ten Einstein equations are really only six independent differential equations for the six functions among the ten $g_{\alpha\beta}$ that characterize the geometry independently of the coordinates.
>
> Bernard Schutz, §8.2

> . . . the first step in the solution of any problem in GR must be an attempt to construct coordinates that will make the calculation simplest.
>
> Bernard Schutz, §8.3

8.1 Exercises

8.3 (a) Calculate in geometrized units:

(i) Newtonian potential of the Sun at the surface of the Sun.
(ii) Newtonian potential of the Sun at the radius of the Earth's orbit.
(iii) Newtonian potential of Earth at the surface of the Earth.
(iv) Speed of Earth in its orbit around the Sun.

8.3 (b) You should have found that your answer to (ii) was larger than to (iii). Why, then, do we on Earth feel Earth's gravitational pull much more than the Sun's?

Solution:

The solution I offered in (Scott, 2015) is incomplete[1]. It is important to mention that the Earth's obrit about the Sun is a geodesic. Effectively the Earth is in free-fall, the centre of the Earth providing an approximate inertial reference frame. In Newtonian terms, the gravitational pull of the Sun's potential gradient has been eliminated by the free-fall of the Earth in its orbit about the Sun. Here on the surface of the Earth, we are only about 6370 km from the centre of this inertial frame, and feel only the tide-generating potential resulting from the non-uniformity of the Sun's gravitational potential gradient. This is about half that of the Moon's tide-generating potential (Misner et al., 1973, Exer. 1.2). In contrast the Earth provides a much weaker gravitational potential but we are not in free-fall about the

[1] I thank Mike Clement for drawing this to my attention.

Earth, or at least most of us for most of the time.[2] So we feel this much weaker potential much more.

This is explained well by Schutz :

http://www.aei.mpg.de/~schutz/download/FirstCourseGR2.Solutions.1_0.pdf.

[2] My 5-year-old son provides a notable exception to this general statement. He's taken to jumping up and down when he gets excited, which is actually most of the time, so he feels Earth's gravity only for the brief moments of the waking hours that his feet are firmly on the ground.

References

Misner, C.W., Thorne, K.S., and Wheeler, J.A. 1973. *Gravitation*. San Francisco: W.H. Freeman.

Scott, Robert B. 2015. *A Student's Manual for A First Course in GENERAL RELATIVITY*. Cambridge UK: Cambridge University Press.