13.5: Effects of Relativity

So far our discussion of gravity has been completely non-relativistic. We will not explore in detail how the theory of gravity changes in a completely relativistic treatment. As we noted earlier in the course, Einstein's general theory of relativity covers this, and the mathematics are formidable. We confine ourselves to two comments:

- As noted previously, gravity is locally equivalent to being in an accelerated reference frame. However, unlike the simple example which we studied earlier, there is in general no universal frame of reference that is everywhere inertial to which we can transform.
- Space is even more non-Euclidean in general relativity than in special relativity. In particular, there is no such thing as a straight line in the geometry of general relativistic spacetime. This is true because spacetime itself is curved. An example of a curved space is the surface of a sphere. Clearly, a straight line cannot be embedded in this space. The closest equivalent to a straight line in a curved space is a **geodesic curve**. On a sphere great circles are geodesic curves. In general relativity, objects subject only to the force of gravity move along geodesic curves.

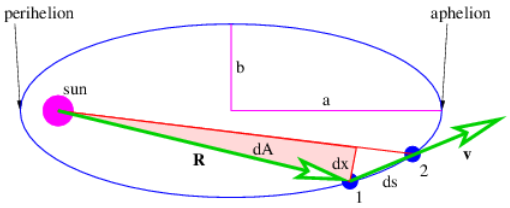

Figure 13.5.7:: Illustration of elliptical orbit of a planet with the sun at the left focus. The **semi-major** and **semi-minor axes** are denoted by a and b. The shaded triangular area element is needed for the discussion of Kepler's second law. **Perihelion** and **aphelion** are respectively the points on the orbit nearest and farthest from the sun. Note that at perihelion and aphelion the velocity is purely tangential, i. e., the velocity component along the radius vector is zero.

One potentially observable prediction of relativity is the existence of gravitational waves. Imagine two stars revolving around each other. The gravitational field from these stars will change periodically due to this motion. However, this change propagates outward only at the speed of light. As a result, ripples in the field, or gravitational waves, spread outward from the revolving stars. Efforts are currently under way to develop apparatus to detect gravitational waves produced by violent cosmic events such as the explosion of a supernova.