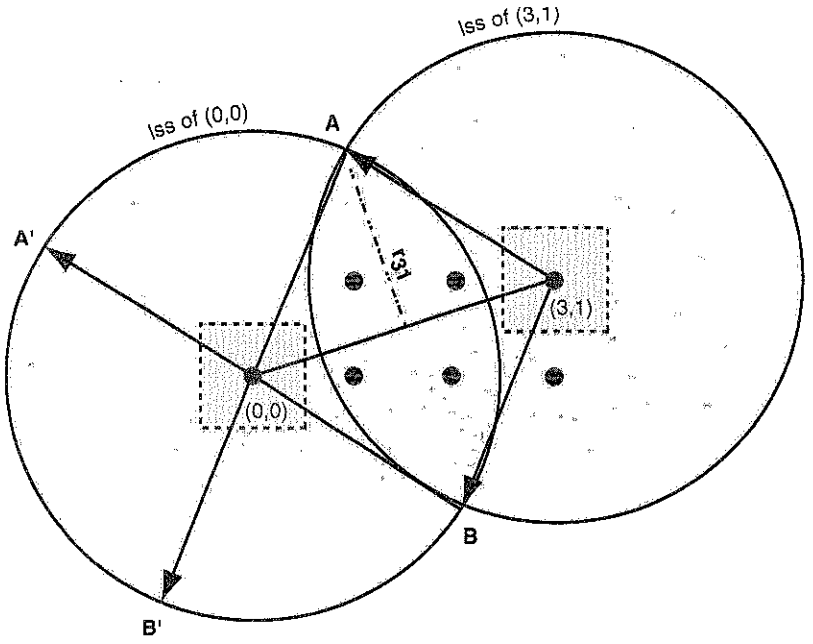

Figure 21.3. Principle of the method of matched circles. The method of matched circles is illustrated here in a wraparound space of two dimensions (a torus). The fundamental polyhedron is a square (with a dotted outline); all of the dark gray points are copies of the same observer. The two large circles (which are normally spheres in a three-dimensional space) represent the last scattering surfaces (lss) centered on two copies of the same observer. One is in position (0, 0); its copy is in position (3,1) in the universal covering space. The intersection of the circles is made up of the two points A and B (in three dimensions, this intersection is a circle). The observers (0,0) and (3, 1), who see the two points (A, B) from two opposite directions, are equivalent to a unique observer at (0, 0) who sees two identical pairs (A, B) and (A', B') in different directions. In three dimensions, the pairs of points (A, B) and (A', B') become a pair of identical circles, whose radius r_{31} depends on the size of the fundamental polyhedron and the topology.

Let us consider two different views of the Universe: one taken from Earth and the other taken from a distant galaxy. Every extraterrestrial astronomer living in this distant galaxy sees a surface of last scattering different from ours (Figure 21.3).

The map of the diffuse cosmological background that he develops will have, of course, an average temperature of 2.728 K (a reflection of the temperature of the entire Universe), but the pattern of fluctuations around this average will be

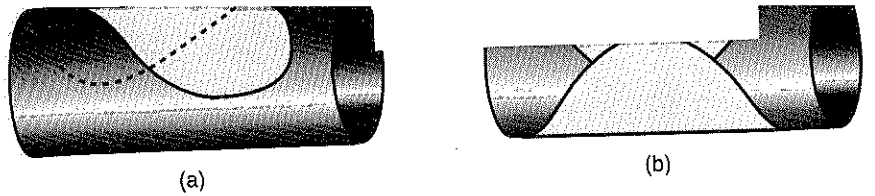

Figure 21.4. Self-intersection of the last scattering surface. In order for an observer to see matched pairs of circles in the fossil radiation, the last scattering surface must be sufficiently large with respect to the size of the fundamental polyhedron. In this example of a two-dimensional cylindrical universe, the border of the disk of paper represents the last scattering surface. In (a), the perimeter of the cylinder is larger than the disk, because of which the disk does not intersect itself: the observer will not see any pair of matched circles. In (b), the disk completely wraps the cylinder and overlaps itself: the observer will see the last scattering surface intersect itself in the form of circle pairs.

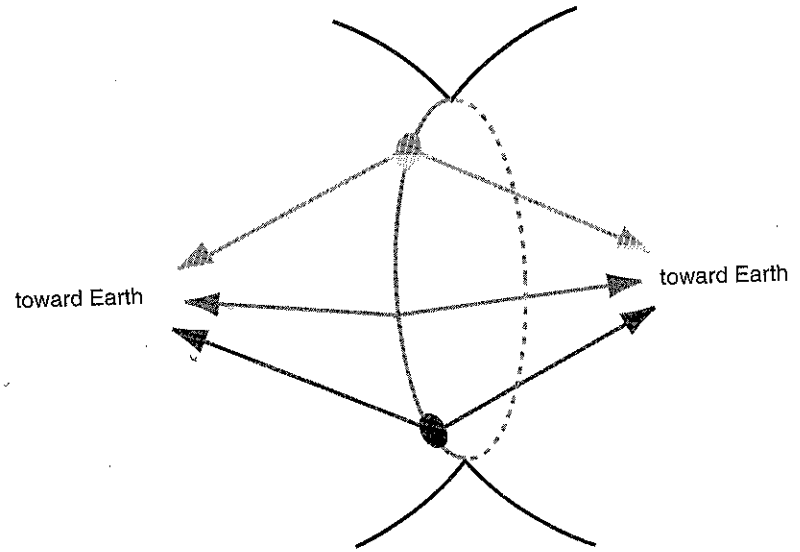

Figure 21.5. Homologous circles. If the last scattering surface wraps around the Universe, it intersects itself. The circle of intersection is visible from the Earth in two different directions, in the form of a pair of matched circles. The temperature varies slightly along the circle of intersection, sometimes cooler (the dark zone), sometimes warmer (the light zone). The corresponding photons are slightly less energetic (dark rays) or more energetic (light rays) with respect to their average energy (medium rays).