

Does the Universe have a twist?

Jayant Narlikar on the surprising speculation that the cosmos we inhabit is bent and elliptical

IN HIS celebrated book *One Two Three... Infinity*, the late George Gamow mentioned the possibility of space having a twist. Said Gamow: "... on a twisted surface a right-handed object can be turned into a left-hand one, and vice versa, by merely carrying it round the twist... If this is really so... the manufacturers of gloves and shoes would have the dubious advantage of being able to simplify production by making only one kind of shoes and gloves, and shipping one half of them around the universe to turn them into the kind needed for the other half of the world's feet."

Gamow mentioned this idea in a non-serious vein more as an abstract mathematical result than as a realisable physical fact. However, nature has been known to take seriously what people may consider too bizarre to be real. In the early days of general relativity the concept of curved space and time was regarded as esoteric: not so now. What with black holes and the expanding Universe, space warps are now an accepted part of the theoretical astrophysicist's paraphernalia.

What about space twists? The apparently far-fetched example of the Möbius strip does find an echo in the models of the expanding Universe. The most favoured models today are those first proposed by Alexander Friedmann in 1922. Einstein's equations, interpreted by Friedmann, determine the geometrical parameters of space and time, but the question of *connectivity* remains unsettled.

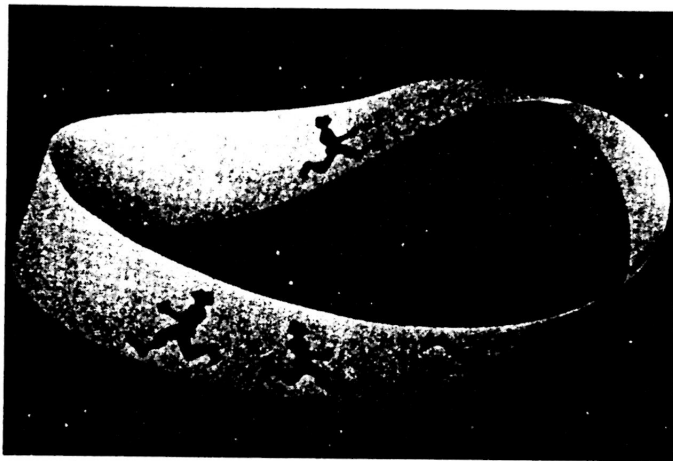
Connectivity is a topological property of space giving meaning to such concepts as the "inside" and "outside" of a closed curve. The surface of a circular cylinder and the plane surface both have zero curvature: but if we go round the axis of the cylinder we return to the starting position. There is no equivalent path on a plane surface. They have different connectivity.

Friedmann's models of the Universe include a version, called the elliptical model, which has a different kind of connectivity from what we think of as common sense.

In his book *The Expanding Universe*, Arthur Eddington likened the elliptical universe to a Möbius band made of blotting paper (Forum, 22 November 1984). An ink spot on the paper seeps through to the other side: both sides of the dot are one and the same. The elliptical universe is like that, but in four dimensions.

How can we tell if the real Universe is like that? The analogy of the two-dimensional surface of a sphere helps in visualising this effect.

On the spherical surface of the Earth, the great circles play the role of straight lines. The great circle through any two points is divided into two parts, one of which is



A Möbius strip is easily made by pasting together the ends of a long rectangular band after giving it a twist as shown above. The flatman running along the strip appears to have changed to his reflection after completing one round.

longer than the other unless the points are diametrically opposite. From one point, we can set out in two opposite directions in order to travel to the second point. In the Friedmann model there are similarly two straight-line paths connecting any two points and since light travels along such straight lines we expect to see two images of an astronomical object. One image, formed by light travelling along the shorter route, will be brighter than the other image in the diametrically opposite direction formed by light coming along the longer route.

But in the simplest Friedmann model – the “spherical” Universe – the time needed for light to reach us the long way round is more than the time since the Big Bang, the

age of the Universe. Only one image is seen. The elliptical model is smaller, however, and permits two images to be seen. This is a new discovery that I made with T. R. Seshadri (*Astrophysical Journal*, vol 288 p 43, 1 January 1985).

The red shifts of the two images (called the direct and the counter images) can be calculated. For both the images to be seen, the red shift of the direct image must exceed a certain minimum value. For plausible assumptions about the real universe, this

red-shift limit (z) is about one.

The counter image will have a much larger red shift, as high as 10, and be very faint. The largest red shifts yet observed are less than four, so tests of the ellipticity of our Universe require improvements in observing technology. With the rapid advances on the electronics front and the imminent launching of the space telescope, the proposal to look for the counterimage of a bright high red-shift quasar, lying in the diametrically opposite direction, may not, however, seem impracticable in the near future. And if we do see doubles we will have clear evidence that we live in a *twisted* as well as a warped Universe. □