What is angular momentum and why are there disks?

Angular momentum is the motion of a quantity of matter about an axis of rotation. A wheel on a moving car has angular momentum. If the wheel comes off the car, it retains its rotation and can roll independently down the highway in a direction which is initially the same as when it left the axle.

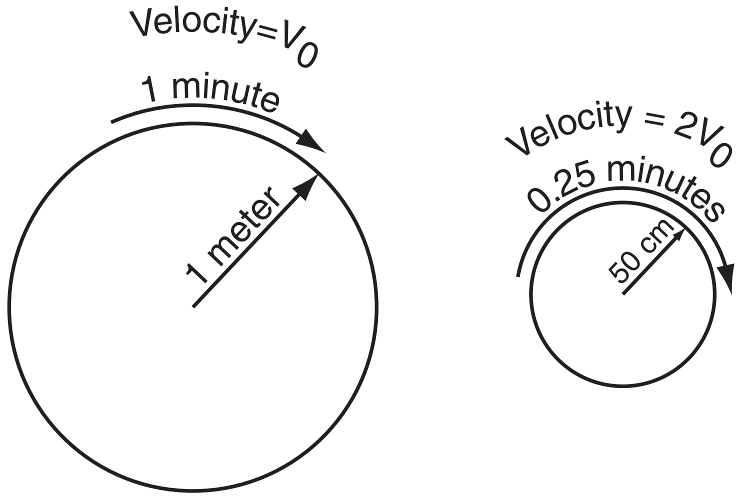
The product of the mass of matter and the distance from the axis of rotation is called the angular momentum. This quantity is conserved in that if the distance decreases, the rate of rotation increases. This conservation is used by ice skaters when they increase their rate of spin by moving their arms inward.

Water going down a drain pipe illustrates the conservation of angular momentum as well. There is generally a small amount of spin to the water in the basin. When the water flows toward the drain to go down, its angular momentum is conserved and it increases its rate of spin as it gets near the opening. At the last point above the drain, a tight whirlpool can be formed with vertical sides.

In order to keep the wheel together as it rotates, there must be a force holding its outer edge in. Any matter moving without a force applied to it moves in a straight line. As the rim of the wheel stays near the axle as the wheel rotates, it undergoes a continuous change in velocity called a centripetal acceleration. If we were to imagine putting our bus for the Rolling Stones Resurrection Tour on a large turntable like that in an old railway house and were to spin the laboratory on this turntable, the walls and seats would appear to be stationary but the occupants would know the bus was rotating because they would feel an apparent force called the centrifugal force.

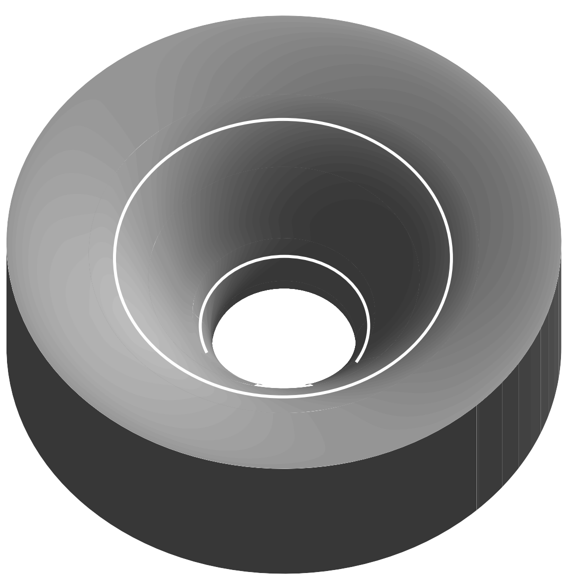
The cosmic democracy principle does not apply to the spinning bus because it is not moving uniformly in a straight line. Observers on this bus make observations which are different from those of non-spinning observers. For example, light does not move in a straight line.

Rotation and centrifugal force



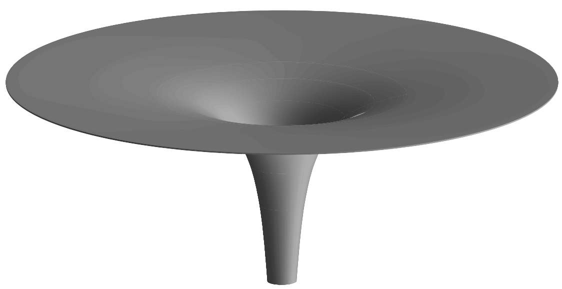
The rings have the same angular momentum. The ring on the left has a radius twice that of the ring on the right. Conservation of angular momentum requires the velocity of the ring rotation to double. Since the radius of the ring is now half of before, the ring can complete its rotation in one quarter the time.

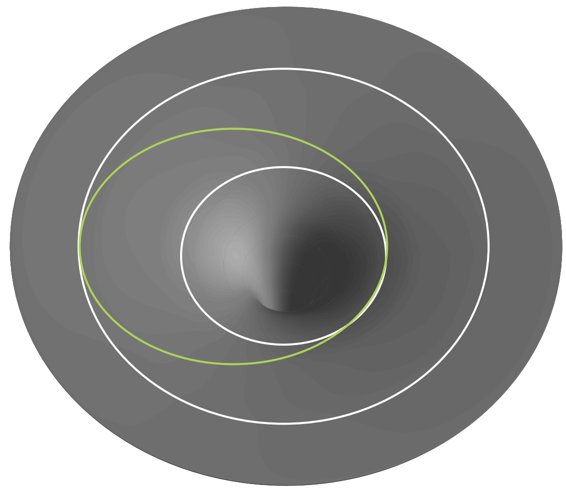
The conservation of angular momentum causes there to be a need for an increasing force to retain the moving ring. In the case of a circulation motion in the atmosphere, the retaining force comes from a pressure gradient through the ring. A structure like a tornado or hurricane involves this process. The circulating air conserves its angular momentum so that its velocity increases and the retaining force also increases. This builds up a steep pressure change. Since the pressure outside the vortex is the normal atmosphere, the pressure inside the vortex must be small.



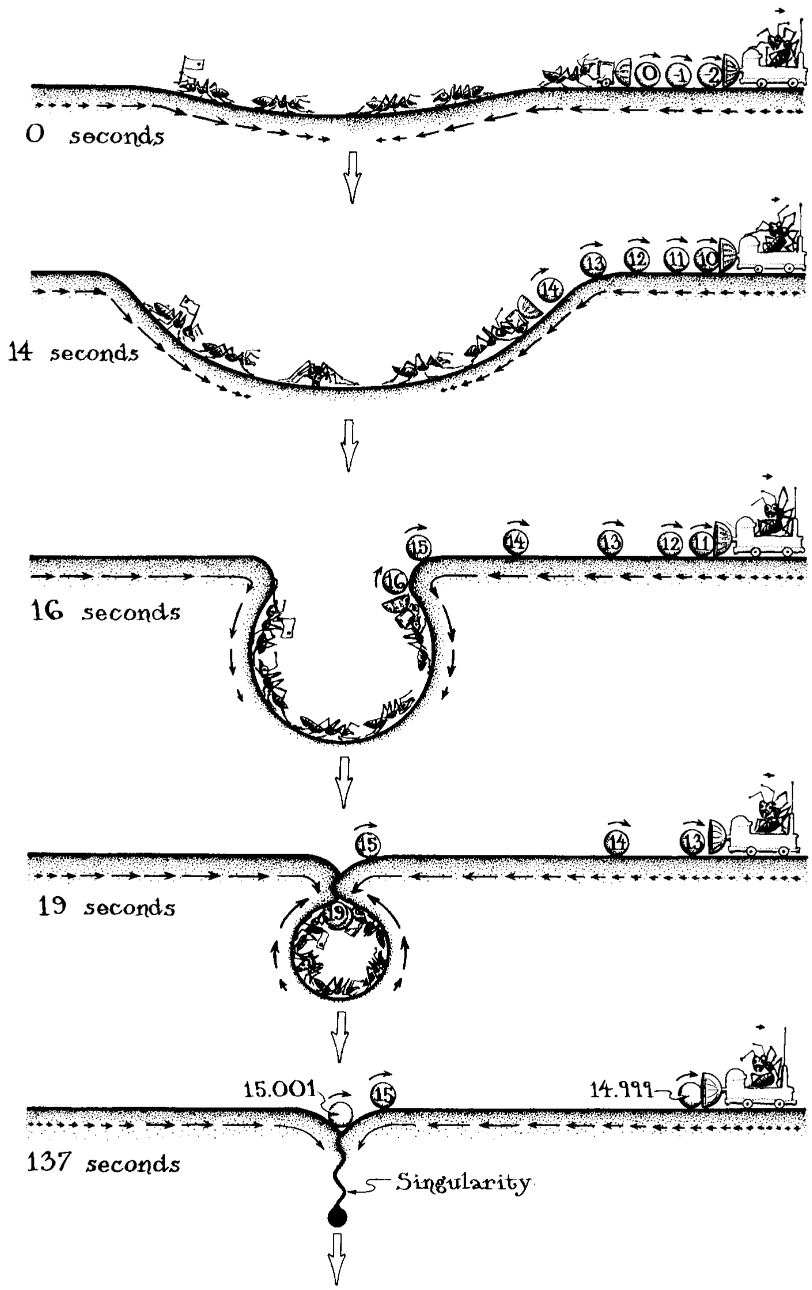
Representation of Orbits on a curved surface

It is possible to visualize the motion of a particle in a gravitational attraction field by means of a curved surface on which a particle can roll or slide. The vertical direction represents the energy available to the particle when it moves along the surface – if it is lower, it acquires some potential energy which it can convert into energy of motion or kinetic energy. For a gravitational attraction the surface is shaped as below:





We can think of these surfaces as representations of a two-dimensional space. The projections indicate a three-dimensional shape where the vertical direction represents the gravitational energy. The two-dimensional space in this picture can be thought of as being a rubber membrane. Mass placed on the membrane pulls it down like water pooling on a rubber sheet. The concentration of mass into a point would pull the sheet down into a very deep spout or tube. According to classical theory, this hole could be indefinitely deep and come to an actual point. With the theory of general relativity, the walls of the tube become vertical a the critical black hole radius and the tube is cut off. The sketch below shows a classical gravitational point:



This diagram shows how a colony of ants living on a membrane can cause a collapse of the space-time represented by the membrane. As they gather in a depression (the center of their mutual gravitational attraction), the distort the membrane downward. This represents the fact that it now takes energy for an ant to climb up the side. They are also sending out signals to the ant on the edge telling this remote observer what is happening to them. As too many of them are collected in the center, the membrane begins to stretch more and more quickly. This membrane stretching pulls the signal balls in toward the trapped ants and eventually no more signal balls can leave. This is when the membrane becomes vertical on its side. The trapped ants can continue to fall inside their trapped region but they can no longer tell the remote ant what is happening.

Representation of gravity as a membrane

The use of the distorted membrane to represent the gravitational field associated with matter is a reasonably accurate approach and is used by those who study the mathematics of black holes to visualize dynamics near the event horizon.

Black holes can have only three properties:

1. Mass.

2. Angular Momentum.

3. Electric Charge.

Even though the list of properties is limited, the mathematics is very complicated and only the simplest cases are understood completely.

Near the critical radius, there are possible processes which permit the formation of what amounts to an atmosphere for the black hole. What we see at a distance is governed by what happens in the black hole atmosphere. The use of membranes allows the description of the movement of photons near the black hole.