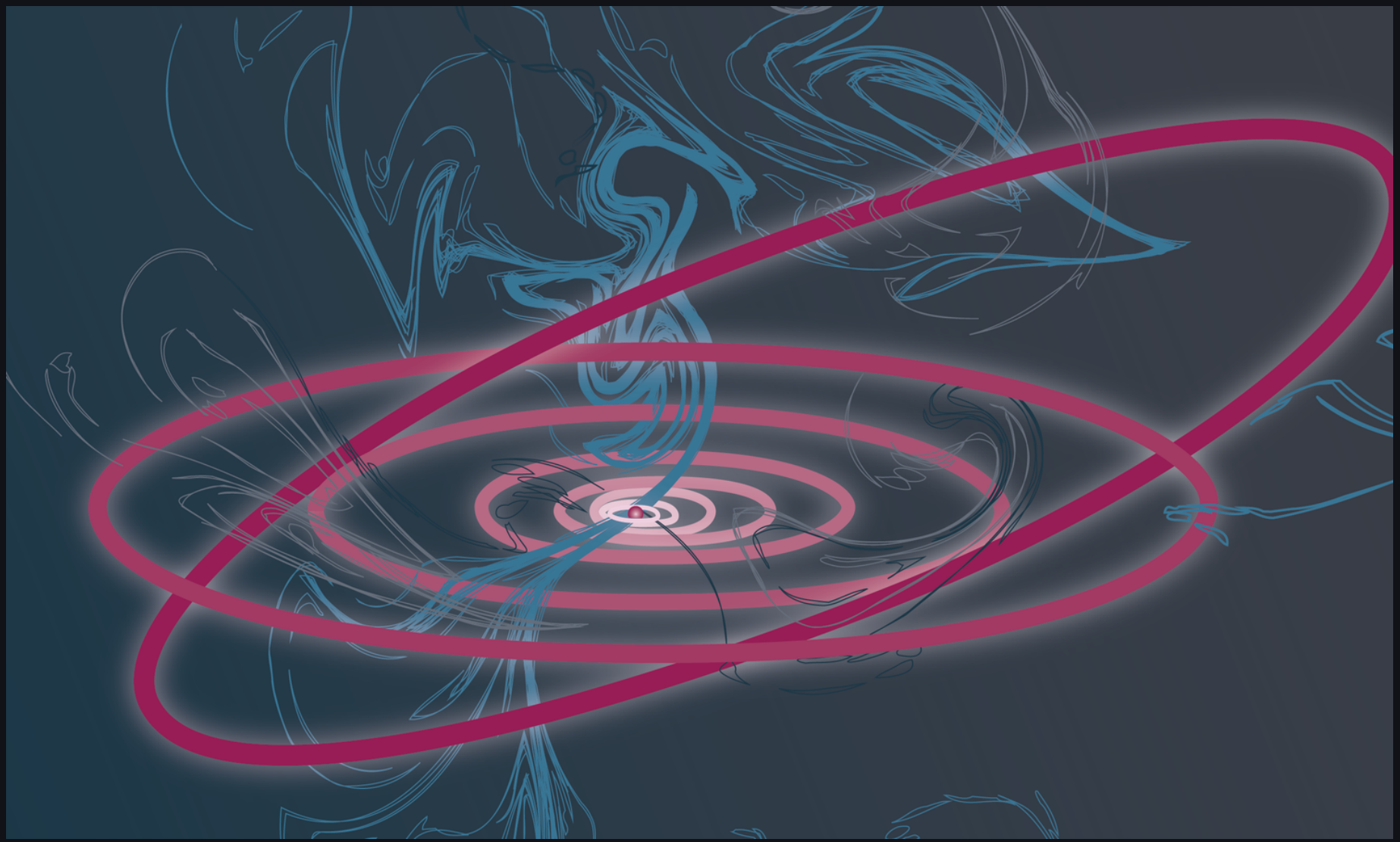


Feb 28

What Causes Inertia?

Astrophysics & Cosmology, Material Science, Mechanics

Last time, we looked at the idea of a limit on the speed of light. We reasoned that all physical motions are slowed for one of two reasons: because other objects get in the way or because something pulls on them. Today we'll look into the cause of Newton's observation that an object at rest or in motion remains so unless pressured otherwise. That this object will push back against such an interceding pressure, even in outer space, is called the phenomenon of inertia. Let's demystify inertia.

Inertia means tendency toward idleness, from the Latin *iners*. Some examples of inertia are easier to rationalize than others. Imagine a ball sitting atop a mountain. Without us pushing (accelerating) the ball it stays on top of the mountain. This is easy to understand: the upward pressures acting upon the ball due to friction from below and gravity pulling downward are equalized. Air pressure from each side of the ball is equalized as well.

If our ball does not move, it is because all external pressures are balanced.

If we pressure the ball to move and nudge it over the lip of the mountain, gravitational pull will take over and the ball will gain velocity and momentum in proportion to this. The ball's momentum reflects its mass, a measure of gravitational pull, which grows based on the quantity and quality of its atomic composition. We could say that momentum

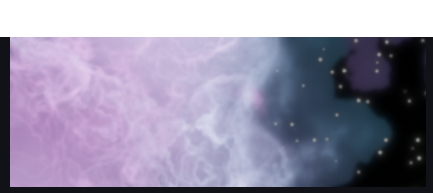
quantifies a body's inertia once it is in motion. Without motion, inertia can only be gauged by mass. Think about it; heavy objects at rest are difficult to displace. On Earth, inertia makes a lot of sense.

But what about a spacecraft trying to navigate around an asteroid field in the weightlessness of outer space? Here there are also few frictions to impede the forward motion of the craft and no local gravity holding it in place. So what happens during a turn to avoid an on-coming asteroid? Must the craft reckon with inertia? Yes, there is some hidden pull present, which resists the spacecraft's adjusted acceleration even in outer space!

The astronauts onboard the spacecraft feel something similar to gravity during the turn, which pulls them to the side of the craft opposite the new trajectory.

Engineers have imagined harnessing this sort of inertial pull to provide artificial gravity on future space stations by continually rotating them.

So what *is* the cause of this on-demand gravitation in outer space, away from large bodies like Earth? The answer seems to have been put forth by Ernst Mach in the mid 19th century. Mach suggested that simply removing the spaceship from Earth's gravitational dominion does not remove the Earth's gravitational influence altogether, but merely dilutes its authority. By this same principle, each of the adjacent bodies in the solar system indeed exerts some non-dominant but important gravitation effect upon the spacecraft. Even the asteroid, which the craft is turning to avoid, pulls some upon the ship. In other words,



In the Lab...

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Apr 18, 2021, 2:12 PM

all bodies surrounding the ship, however distant, large or small, will pull upon it. The net effect of this universal pulling is what we signify with the concept of inertia.

What Mach suggested was rather profound, if only for its simplicity. Inertia means that all of your atoms are gravitationally entwined with all of the atoms around them. And though our everyday inertial experience is ruled by the multitude of atoms comprising the Earth, **you can test your connectivity to the rest of the surrounding universe with a simple experiment: Fill a cup with water and with your arm outstretched, spin around in a circle.** You will notice that the water "sticks" to the side of the cup. The water has very little friction holding it to the side of the container. And if only the Earth's gravity were at play, the water would fall level with the horizon. The only explanation for what you're observing, is that all of the other atoms in your world, including the atmosphere, sun and stars, are indeed exerting some meaningful pull upon the water to resist its relocation. The mechanism by which one of those atoms pulls upon yours remains a topic ripe for investigation.

gravity, unity, physics

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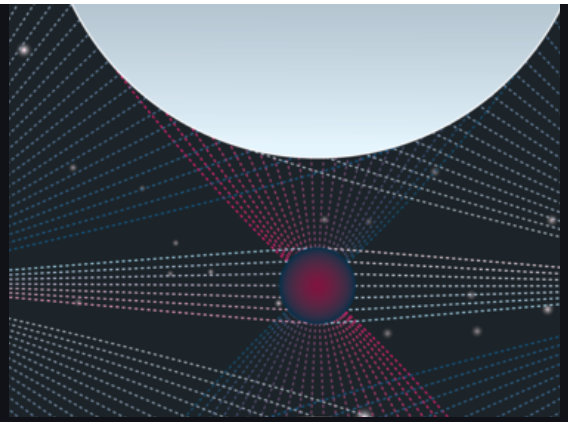

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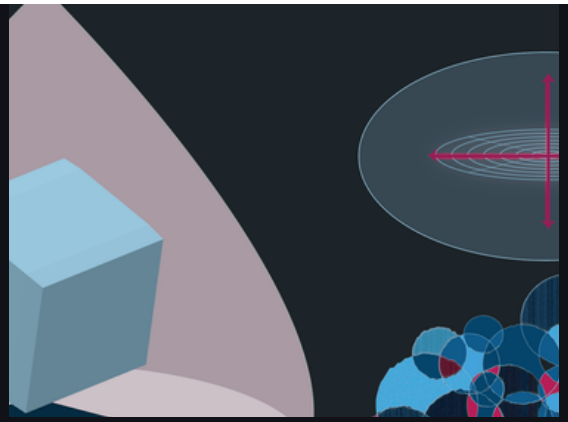

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