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Abstract: The article discusses how energy can never be lost or destroyed, only transformed. Kinetic energy and gravitational potential energy are discussed. The star Betelgeuse is discussed in terms of its potential energy being transformed into kinetic energy, forming a supernova. The fundamental forces of the strong force, the weak force, electromagnetism, and gravity are discussed.

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Section: BOB BERMAN'S STRANGE UNIVERSE

Energy to spare

Wherever we look, we see energy. Yet, most people have no idea what it is. Einstein wrote in 1905 that matter and energy are equivalent. Each can change into the other. A slice of cheddar cheese is natures way of storing nearly a trillion ergs of energy. If you could convert the cheese instead of melting it, you could light up all the houses in a small city.

Astronomers lump the universes mass and energy together. Unless there are other universes we don't know about, this total energy inventory is finite — yet we can't use it up. Energy is never lost, never destroyed, never born. Energy changes form, but it never diminishes in the slightest.

Say you drive up a hill, and then let the car coast back down. You started by releasing gasoline's chemical energy, which had been stored in its molecular bonds. Energy that's stored or "waiting to happen" is called potential energy. By making your car move, the fuel's potential energy changes into the energy of motion: kinetic energy. Even light, because it moves, possesses energy, which means it has an equivalent mass. It just doesn't have a "rest mass" because, unlike everything else, it's weirdly compelled to always move. If you could make light stop, it would disappear.

Ever been hit in the face with a cream pie? Take it from me, it doesn't really hurt when it's merely squished into your face. But it can be painful if the pie is actually thrown, because a moving pie has kinetic energy. Any celestial body that spins, moves, or contains jiggling atoms — in other words, everything — seethes with kinetic energy. It's everywhere.

Anyway, as your car goes uphill, it actually gains energy — the potential energy of gravity, meaning that when you arrive at the top, you get a coupon for a free ride back down. The coupon never expires. That gravitational potential energy would patiently wait for a million years. But say you squander it immediately and coast downhill, gaining kinetic energy, while using up this gravitational potential energy. When you hit the brakes at the bottom, the car's kinetic energy gets transferred into heating the brakes. Heat is simply atoms in motion, which is more kinetic energy. Bottom line: Your brief, pointless ride displayed the changing forms of energy. None was ever spent. None was lost. There is only potential energy and kinetic energy, everywhere, assuming various disguises.

Now consider Betelgeuse. This star is on the brink of pulling off an unpleasant surprise for any alien attorneys who have offices on its planets. Someday, Betelgeuse's ancient core won't crank out enough energy to keep pushing its surface outward against its awesome gravity 5 million times greater than Earth's. That potential energy just lurks there like a ticking bomb. When the star collapses, so much potential energy will change into kinetic energy that atomic motion (heat) will suddenly build to unimaginable levels, releasing a brand-new warehouse of potential energy trapped within its atoms. This is a supernova. You don't want to be there.

Energy and force seem similar, but they're different: A force is a push or pull between two objects. Some forces, like the pie, work by physical contact. Others, oddly, act through empty space; no touching is needed.

There are only four fundamental forces: the strong force, weak force, electromagnetism, and gravity. The "strong force" glues protons together, which is a good thing if you value your body and its atoms. This force also keeps neutrons intact. Pry a neutron from its cozy atom-home, and it falls apart in 15 minutes. Leave it alone, and it lasts forever. It's like your car's toolbox.

The strong force works only at short distances about the diameter of a nucleus. That's why giant atoms like uranium are unstable. They're too big. Their outermost protons live where the force is weaker so that one occasionally falls off, changing the atom into a different element. They don't make elements like they used to.

The weak force works solely within atoms, too, and can induce radioactivity. We won't talk about it because nobody cares about the weak force.

Then there's electromagnetism. Its range is infinite. This wonderful force makes motors work and creates particles of light (photons). Photons carry this force from one place to another. When you observe anything through a telescope, what's really happening is that light is bringing the electromagnetic force from far-away empires and delivering it to your retina, where it causes biochemical reactions. In a word, vision. Light isn't just what you see. It's what makes you see.

The fourth force, gravity, is the most mysterious. Nobody really knows what it is. Like electromagnetism, its range is also infinite. It never falls off to zero. Gravity is what glues stars and galaxies together and also can rip them apart.

Force and energy. They're the heart and soul of astronomy.

PHOTO (COLOR)

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By Bob Berman
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