HUDSON
RIVER
MUSEUM

Kitchen Universe

Ages: all (with adult supervision)

Duration: various (observations can be made during the preparation of the food in each activity below)

Materials needed:

- Puffed cereal (like wheat, corn, or millet)
- Your favorite sticky nut butter
- Tomato sauce (or other similar foods)
- Toaster or toaster oven

Introduction:

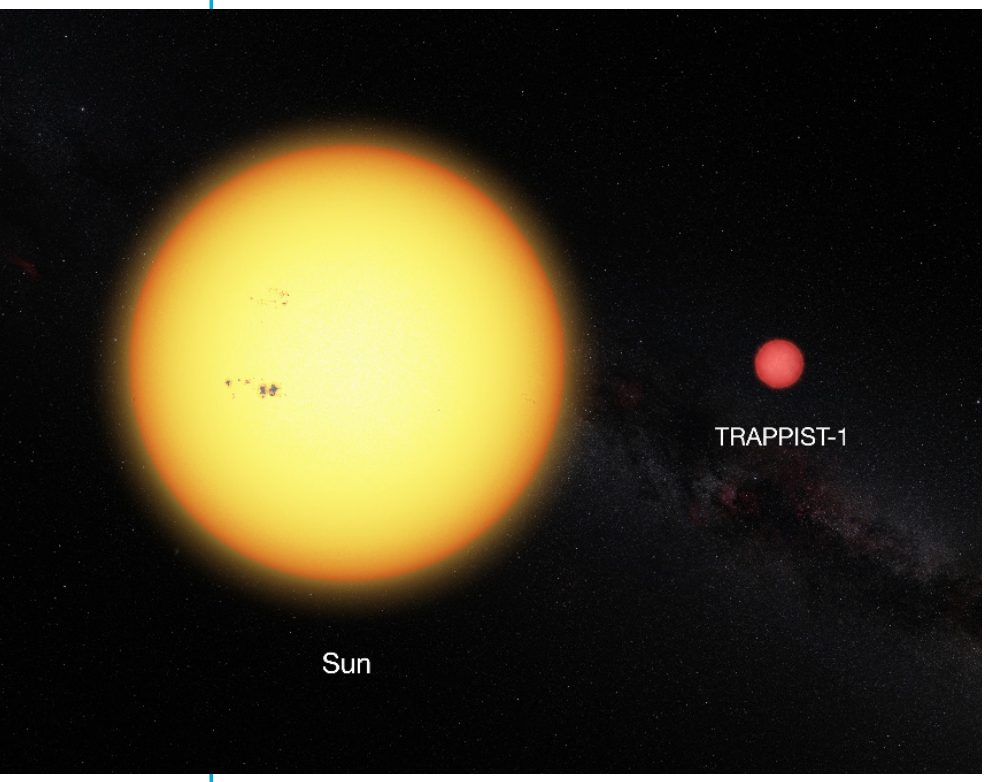
Bring astronomy into the kitchen! Here are some observations you can make and projects to try next time you are cooking a meal or making a snack.

Tomato Sauce & Stellar Flares

All stars turn hydrogen into helium, releasing energy. Massive stars, with high pressures inside, burn through their fuel quickly, lasting only a few tens of millions of years. In comparison, the Sun will last about ten billion years. Red dwarf stars that are smaller than the Sun can last a trillion years; a thousand times longer. You'd think a thrifty star like this would be like a quiet, warm ember, cozy and safe. But it turns out that these low-mass stars are anything but quiet and safe.

These small stars spin faster than the Sun and their interiors are more thoroughly "mixed." This motion twists their magnetic fields into spaghetti piles. These tangled **magnetic fields** act like spray nozzles, blasting any nearby planets with **charged particles**, and scorching them with **flares** hundreds or thousands times stronger than those produced by the Sun.

Here's one way to get a sense of what this is like: tomato sauce! No, tomato sauce is not magnetic... but next time you make some, notice the large bubbles that form in the sauce and burst, spraying the stovetop with droplets. You can think of these as like the magnetic "bubbles" which form within the churning matter of a red dwarf star. Like the bubbles in the sauce, these make it to the surface and pop, propelling clouds of particles into space.

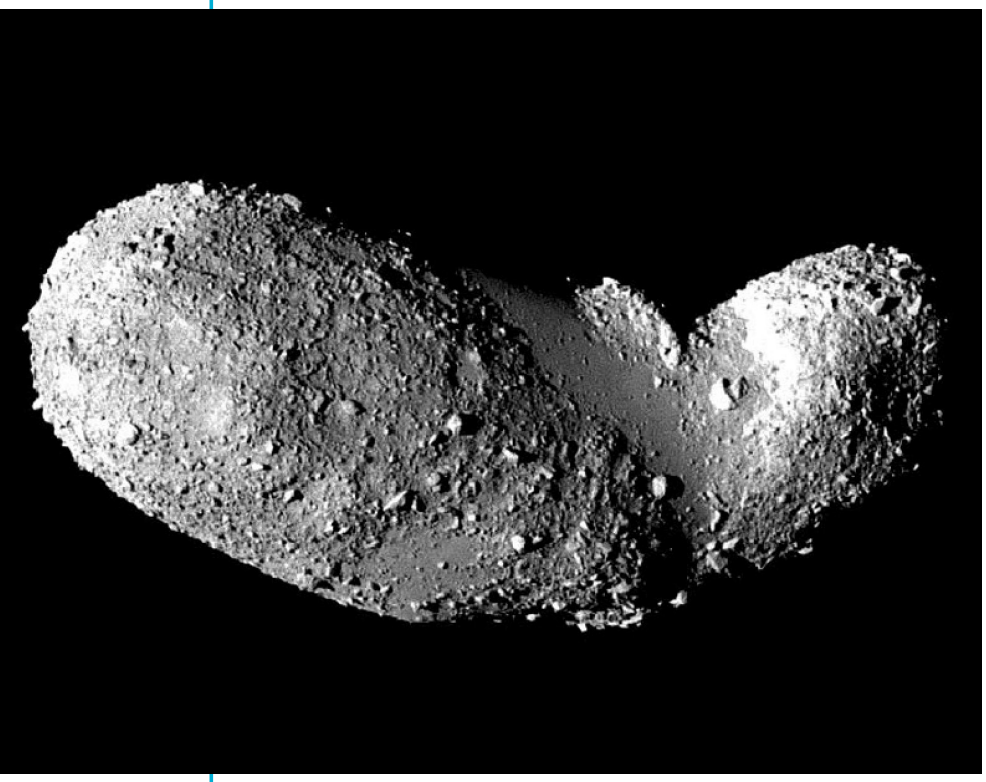


Make a Cometary Comestible or an Edible Asteroid

For at least a century after their discovery, in 1801, we pictured **asteroids** as roundish, solid rocks covered with craters. Since then, we have learned more about them, even sending spacecraft to visit them. Now we know that many are anything but solid. Hundreds and thousands of collisions between asteroids have fractured and pulverized them until some are just rubble piles held together by gravity.

This has all sorts of interesting consequences—even life-or-death implications. But it means that making a model asteroid at home isn't that simple... the gravity of the Earth will overwhelm the self-gravity of a handful of pebbles. It will be easier, instead, to make a model comet.

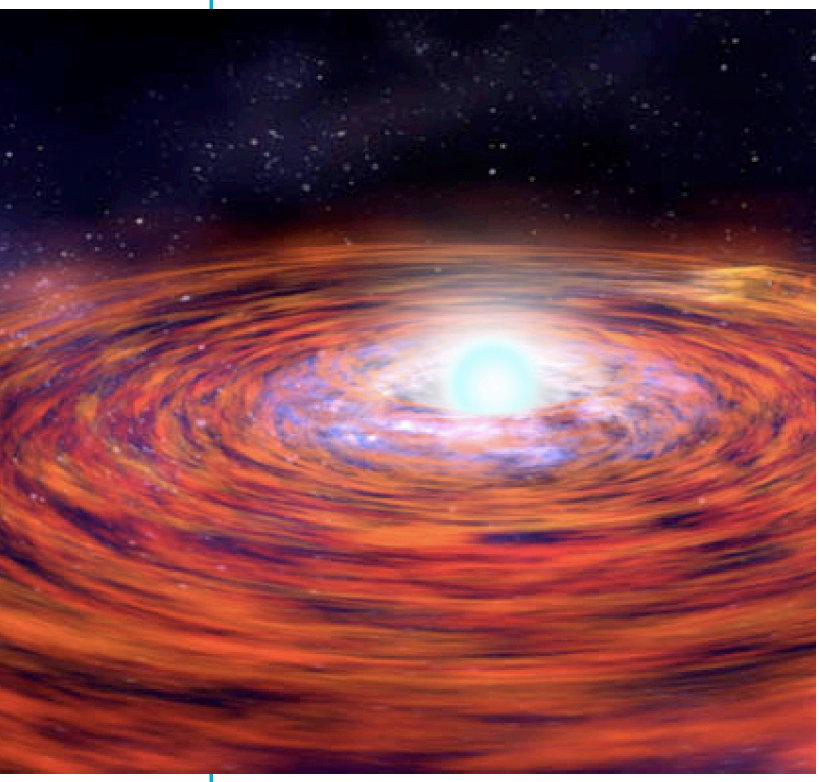
Comets, like asteroids, can also be piles of rubble. But comets are generally glued together with ices, such as water and carbon monoxide, which vaporize as they near the Sun. You can simulate this by taking a handful of puffed grain cereal as "boulders" and adhere the cereal pieces together using your favorite nut butter for the "icy" glue. Asteroids, like comets, contain ices — just a lot less. There is no clear line between the two, but see how little nut butter you can use, and still have your model hold together. The less you use, the closer you get to making an asteroid!



Pizza & Other Spinning Disks

Has your family been able to use quarantine time to try new cooking and baking projects? Why not try spinning some pizza dough? Not only is pizza delicious (and healthy if you use the right ingredients), it allows you to simulate one of the most important processes in the Universe: *centrifugal shaping of gravitationally bound diffuse astrophysical disks*! What does this mean?

There are disks around stars:
When a pizza chef spins pizza dough and tosses it into the air, the rapid rotation makes the dough spread out into a disk. While the Universe is not full of pizza dough, it is full of clouds of gases and dust, and some of these clouds are swirling around stars and black holes. These are **accretion disks**; black holes, for example, can accumulate matter by pulling apart nearby stars; small, super-dense neutron stars and white dwarf stars, with their strong gravity, can pull gases off of the surface of larger stars.



There are disks that form systems of stars and planets:
Sometimes a disk forms from the collapse of a **nebula**; a cloud of gases, ices, and dusty rubble, each bit of the cloud pulling on every other bit. In this case, most of the material will fall toward the center, and as the cloud shrinks, the sum of all the motions in the cloud (which is never zero) results in an overall rotation. As more material collects in the center, the overall rotation accelerates. This is how the Sun and planets of the Solar System formed, with a massive but relatively slow-spinning star in the center, and a swarm of planets and smaller objects orbiting it.

Some galaxies are shaped like disks:
A spiral **galaxy** is a disk of stars and gases and planets and dust and other objects, looking a bit like a hurricane. It has that shape because—like pizza dough—a galaxy is not a solid, rigid shape, it is rotating, and there is a force keeping it from flying apart (with gravity, not gluten, holding it together). You may have heard that our spiral galaxy, the Milky Way, has a black hole in its center, so you might think that everything in the galaxy is orbiting the black hole. Actually, the rest of the galaxy far outweighs the black hole. The gravity of the stars and everything else in the galaxy, working together, is what holds the galaxy together, and the rotation of the whole system is what maintains the tidy spiral.

Toaster Coils & Stellar Temperatures

No doubt you've noticed that the heater coils in a toaster glow when you push down the lever. Next time you load up your bagel or waffle, push it down and watch more closely. (Just look! Be careful not to touch the hot surface!) Notice not just the changing brightness of the coils in the toaster, but also their changing color.

At first you'll see a dim cherry-red, then a brighter red, then a bright red-orange. You can even confuse your family by waiting for the bread to pop out, and the toaster to shut off, then quickly turn out the lights in the kitchen. Coils that are not visibly glowing in a fully-lit kitchen will be a deep, faint red in a dark room.

This changing color is directly related to the changing temperature of the coils. Stars, too, have colors that are dependent on their surface temperature. Stars cooler than the Sun are redder. The Sun is yellow-white; stars hotter than the Sun are blue-white.

Don't expect your toaster coils to start to glow sun-yellow, though. That would require a temperature of more than 5,800 degrees, about five times hotter than the coils can withstand. You won't see a blue-white glow until your toaster reaches around 20,000 degrees—at which point your toaster will vaporize. If this happens, consult a qualified electrician.

Glossary

Black hole: Black holes are both very mysterious, and the simplest things in the Universe. They are nothing but gravity—all that remains when the core of a star collapses down to a point. Around this point, there is a region of space that nothing can travel fast enough to escape. That includes light, so they are called black holes.

Charged particles: Normally, atoms—one of the basic units of matter—are electrically balanced; they are made of an equal number of positively and negatively charged particles. But the high temperatures at the surface of the Sun can disassemble atoms, and those separate particles can be propelled out into space. If a planet lacks a strong magnetic field, these particles can, over millions of years, strip the atmosphere from a planet, which is the main reason the Earth is alive and Mars seems to be dead. When these particles strike living things, they can break apart the materials that make life possible.

Flares: Stars occasionally produce bursts of charged particles, more than just the constant flow of particles they normally produce simply because they are hot. A flare is when the magnetic field of the star pulls a cloud of charged particles off of the star's surface and propels it into space.

Magnetic fields: You know what magnets are—they are probably all over your refrigerator. The magnet's field is the strength and direction of the effect it has on other magnets, or metal objects, in the space around it. If you measure those effects around the magnet, you'll end up with a map of the field. This is often drawn as a set of lines. The lines aren't really there but they are a convenient way of representing how a magnetic field works.

Nebula: From the Latin word for "cloud," nebula (plural: *nebulae*). Nebulae are clouds of gases and dust grains in space. Some are so dusty that they block the light of stars beyond; nebulae made of gases can glow because the light from nearby stars makes the gas molecules light up like a neon sign. Left undisturbed, the gravity of all the dust grains and gas molecules will eventually make the cloud collapse, forming stars and planets.