PHYSICS UPDATE

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HOW STARS VISIT THE SOLAR NEIGHBORHOOD

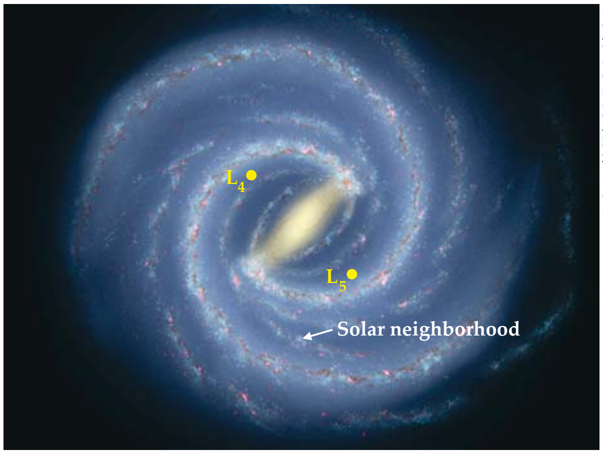
About 10% of the stars in the solar neighborhood belong to a large group that exhibits an oddly distinctive collective motion. Known as the Hercules stream, the group includes stars that are moving away from the center of the galaxy while falling behind the galaxy's general rotation. The cause of that motion is the subject of a new study by Angeles Pérez-Villegas and her colleagues at the Max Planck Institute for Extraterrestrial Physics in Garching, Germany.

New stars typically condense with other new stars out of the same dense cool region of gas and dust. Because stars are born more or less around the same time, they inherit the motion around the galaxy of their birthplace. The Hercules stream is different. Spectroscopic observations have revealed that it's made up of stars of widely different ages. Whatever is causing the streaming motion operates across large scales of time and space.

One candidate is the dense central bar of stars from which two of the galaxy's spiral arms sprout (see accompanying figure). The solar neighborhood lies beyond the orbit of the ends of the bar, but the Sun and the stars of the Hercules stream are close enough to feel the bar's gravitational influence. Generally speaking, as stars orbit the galaxy, they oscillate toward and away from the galactic center. If a star's radial oscillation resonates with the bar's rotation, the star can end up with an extra kick away from the galactic center.

That resonance, the outer Lindblad resonance (OLR), has been invoked to explain the Hercules stream, but new observations have identified a flaw in the explanation. The bar rotates more slowly than originally thought. Consequently, the OLR is too far away from the solar neighborhood to be the stream's prime mover.

Pérez-Villegas and her colleagues used those new observations to test a detailed dynamical model of the stars in and around the bar. The model not only re-created the positions and velocities of the Hercules stream, it also revealed what causes its unusual motion: The stream's stars are orbiting two local maxima—the L_4 and L_5 Lagrange points—in the bar's effective gravitational potential. The maxima are situated on the bar's perpendicular bisector close to the distance where stars corotate with the bar. In the model, most of the stars in the Hercules stream originate from the inner part of the galaxy, where the stars tend to be older than the Sun. Their looping orbits around L_4 and L_5 take them all the way into the solar neighborhood, but not much beyond it. (A. Pérez-Villegas et al., *Astrophys. J. Lett.* **840**, L2, 2017.) —CD



NASA/JPL-CALTECH/ESO/R. HURT

PRINTING GLASS IN 3D

NEPTUNLAB/KIT

These days it seems you can make anything with 3D printers—but not if you want to make it out of glass. The main complication is that the printers create structures that are rather coarse, at least at the millimeter scale and smaller. For glass, such a rough surface hinders the transmission of light.

Now Bastian Rapp at the Karlsruhe Institute of Technology in Germany and colleagues have used off-the-shelf chemicals and a commercially available 3D printer to create transparent structures out of glass that is nearly indistinguishable from pure fused silica glass. The team's big advance was dissolving large amounts of silicon dioxide nanoparticles—between 30% and 45% by volume—in their polymer "ink." A $7500 stereolithography printer composed the desired structure layer by layer using the silica-infused polymer. After burning off the polymer, Rapp's team sintered together the enduring nanoparticles at 1300 °C to create the final solid product (such as the one shown here). Both Raman spectroscopy and x-ray photoelectron spectroscopy confirmed that the printed glass, which was highly transparent for wavelengths above 350 nm or so, had nearly identical optical properties to fused silica.

Printed optical-grade glass could prove useful for lenses, fiber-optic cables, and photonic applications. And because the technique doesn't require a custom printer, the properties of printed glass should become even more finely tunable as 3D printing technology improves. Rapp hopes to devise a similar nanoparticle–polymer mix for soda-lime glass, which is used for everyday items like windows, windshields, and drinking glasses. (F. Kotz et al., *Nature* **544**, 337, 2017.) —AG

SHEDDING LIGHT (AND DARK) ON QUANTUM PROBABILITIES

For more than a century, Thomas Young's seminal double-slit experiment was seen as a convincing demonstration that light is a wave phenomenon. The modern interpretation provided by quantum mechanics is radically different: Light comprises discrete entities called photons, and the photon wavefunction at a given location on a detector screen receives contributions from all paths that pass from the photon source through the slits (call them A and B) and on to the screen. The intensity at any location on the screen is proportional to the probability that the photon arrives at that location. According to the Born rule, that probabil-