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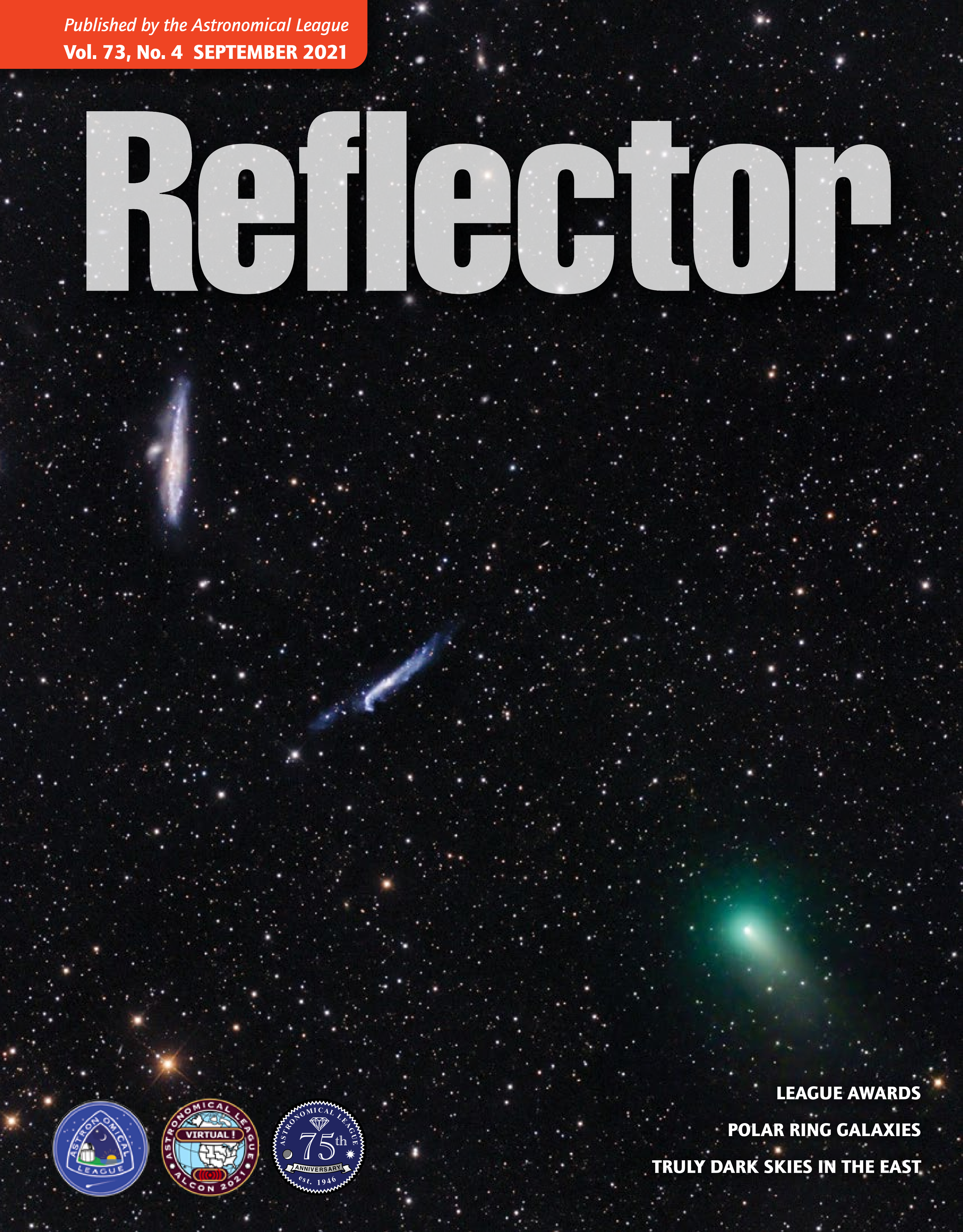
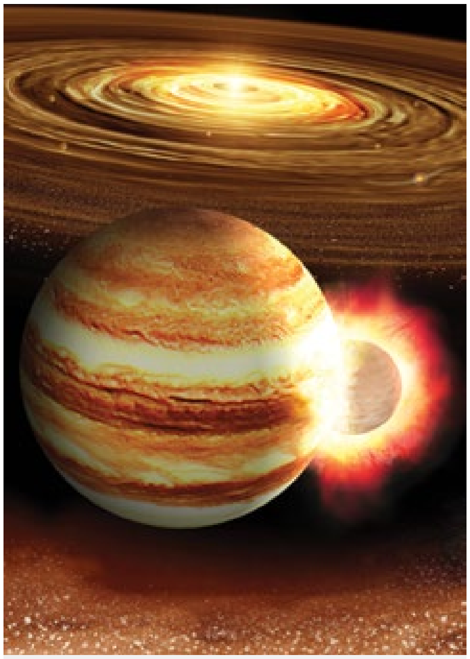
Reflector



LEAGUE AWARDS

POLAR RING GALAXIES

TRULY DARK SKIES IN THE EAST



An artist's rendering of the impact of a protoplanet with the proto-Jupiter around 4.5 billion years ago. This impact scattered the rocky material throughout the central half of Jupiter. It is thought that it will take many billions of years for the rocky core to reform. Illustration by K. Suda and Y. Akimoto/Mabuchi Design Office, courtesy of Astrobiology Center, Japan

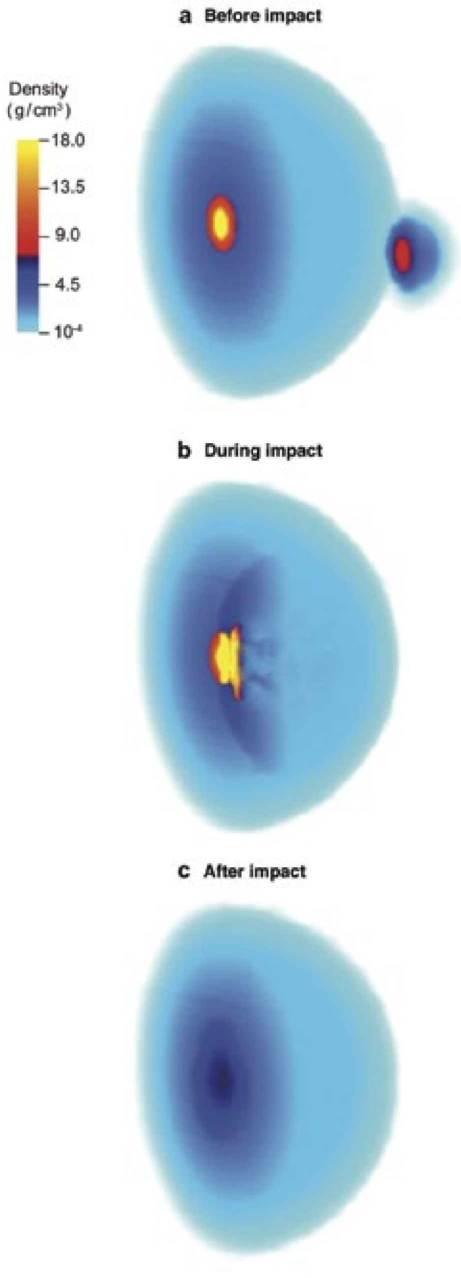
from Juno, the speed of the spacecraft relative to Earth can be computed. By taking many measurements of the Doppler-shifted radio signal, the exact shape of Jupiter's gravitational field can be calculated. The shape of the field reveals clues to Jupiter's interior.

The calculated map of Jupiter's gravitational field is compared to the field that would be generated by different models of Jupiter's interior. Before Juno, it was assumed that Jupiter had a rocky and icy core at its center. This would have been the initial rocky material that was the earliest part of the proto-Jupiter, accreting material like any other rocky planet. Above the core, metallic hydrogen would occupy two-thirds of the radius of the planet. Floating on top of that up to the cloud tops is a region of helium-poor molecular hydrogen with some trace elements. When astronomers modeled the gravitational field this structure would generate, it did not match Juno's observations.

Since the standard model did not match the observed field, astronomers tried a number of different models. The only model that matched the observed gravitational field is a core of mixed rocky material and metallic hydrogen taking up about half the center of the planet. This is a surprising result, since the rocky core was supposed to be the nucleus of the proto-Jupiter that pulled in hydrogen from the primordial cloud to build Jupiter into the massive object it is today.

The original structure had a clear boundary between the rocky core and the metallic hydrogen above it. In the new model, there is no hard boundary, but a fuzzy boundary between the metallic hydrogen and rocky material mixture and the higher parts of the atmosphere.

Armed with a model that matched the gravitational field shape, astronomers now needed to create a scenario that would result in a fuzzy core.



The interior structure of Jupiter as observed by NASA's Juno spacecraft does not have a rocky core, but the heavier materials are scattered through the central half of the planet. This would not be expected from classic planetary-formation models. A novel hypothesis has a ten- to twenty-Earth-mass protoplanet striking the proto-Jupiter head-on, disrupting its core and scattering the material from both objects throughout the central area of Jupiter. Illustration by Shang-Fei Liu/Sun Yat-sen University

None of the standard evolutionary models would produce it. Astronomers needed a new scenario.

Shang-Fei Liu from Sun Yat-sen University in China and an international team of colleagues put forward a hypothesis that the proto-Jupiter was struck head-on by a rocky protoplanet with a mass of ten to twenty Earths. The impact would have disrupted both Jupiter's rocky core and the interloping protoplanet. Their combined material would have been scattered throughout the region around the planet's center. Modeling showed that even if it happened 4.5 billion years ago, the fuzzy core would still persist for many billions of years.

While it seems that such a collision would be unlikely, the early Solar System was a violent place with frequent collisions. Jupiter's mass would contribute to the likelihood of a collision by pulling in protoplanets. Its gravity would modify a protoplanet's orbit, bringing it closer and closer to Jupiter until it finally collided with the massive planet.

While there is no way to go back in time and observe this major collision, this model has withstood all the tests applied to it thus far. Data are still coming in from the Juno spacecraft that may help confirm or refute this hypothesis. In the meantime, it is a fascinating view of our largest local planet and the violent nature of the early Solar System.

Read more about the impact model here: *news.rice.edu/2019/08/14/young-jupiter-was-smacked-head-on-by-massive-newborn-planet*.

—Berton Stevens

Deep-Sky Objects

THE LITTLE DUMBBELL NEBULA

During the end of a Sun-like star's life it will eject layers of gases. These hot gases will glow for thousands of years forming spherical structures around the star. From our perspective these shells of glowing gas appear as circular or oval-shaped rings. A one-solar-mass star may lose half its mass through this process.These gaseous objects are called planetary nebulae. Of course they are not planets, but in low-power views some do resemble gas giant planets. Thus the name has stuck. Many have blue and green glows not that much different from the planets Uranus and Neptune (for example, NGC 4563 or NGC 7662). Others may appear more like Jupiter and Saturn, such as the Ghost of Jupiter Nebula (NGC 3242) or the Saturn Nebula (NGC 7009).

One of the most interesting planetary nebulae is M76, commonly called the Little Dumbbell Nebula. It has also been known as the Cork Nebula and the Barbell Nebula. Pierre Méchain discovered M76 in 1780 and reported it to Charles Messier for inclusion in his famous catalog. William Herschel thought M76 was two overlapping nebulae, which resulted in M76 receiving two NGC numbers. NGC 650 is the southwestern part of the nebula and NGC 651 is the northeastern part.

Shining at magnitude 10.1, M76 is one of the faintest Messier objects. But it is relatively easy to find. Starting at the magnitude 3.6 yellow star Upsilon (51) Andromedae, hop 2.25 degrees north-northeast to the magnitude 4.0 blue-white star Phi Persei. Fifty arcminutes due north of Phi is an orange star of magnitude 6.7 (SAO 22551). M76 is 13 arcminutes west of SAO 22551.

M76 does not have the typical ring structure of a planetary nebula, so it took a long time for astronomers to determine its true nature. Isaac Roberts studied images he took of it in the year 1891 and determined that M76 was indeed a single nebula. It wasn't until 1918 that astronomer Heber Curtis correctly classified it as a planetary nebula.

The nebula has a cylindrical-shaped bar running from north-northeast to south-southwest that is about 87 arcseconds long and 47 arcseconds wide. The ends of the bar are much brighter than the center. Surrounding the bar is a faint halo consisting of two lobes, one on the northwest side and one on the southeast side. The entire structure is 2.7 by 1.8 arcminutes in size. The nebula is thought to be 2,544 light-years away, making it about two light-years in diameter.

The central star of M76 has a visual magnitude of 15.9 and a photosphere temperature of 88,000 K, much hotter than our 5,700 K Sun. This high temperature is consistent with a star that is in the planetary nebula phase. Over billions of years, the star will eventually cool into a white dwarf.

I took the accompanying image of M76 with an 8-inch f/8 Ritchey-Chrétien Cassegrain telescope with a TeleVue 0.8× focal reducer/field flattener yielding f/6.4. The telescope was on a Paramount MYT German equatorial mount, and an SBIG ST-2000XCM self-guiding single shot color CCD camera was employed. The exposure was 240 minutes using 10-minute subframes. Darks and flats were used. The subframes were registered and stacked using ImagesPlus 6.5 and the final image processing was completed in Adobe Photoshop. In the image, north is up and east is to the left.

The bright star on the left side of the image is the aforementioned SAO 22551. The image captured the nebula's bar with its central star not quite drowned out by the middle of the bar. The outlines of the northwest and southeast lobes were also captured. The faintest stars in the image are slightly brighter than magnitude 18.

The bar-shaped portion of M76 is clearly visible in an 8-inch telescope. Astronomers believe the bar is really a nearly edge-on dusty torus around the star. The optical emissions are thought to be from oxygen IV (triply ionized oxygen atoms). Regardless of the processes that formed M76, the planetary nebula is a great find with any size telescope on a clear autumn night.

— Dr. James R. Dire
Kauai Educational Association for Science and Astronomy

Observing Program Showcase

DARK SKY ADVOCATE PROGRAM

This important activity-based award is unlike any other that the League offers. If you have wanted to do something about a topic so important to our hobby – the loss of our dark skies due to light pollution – this is a way you can help. Here is a great opportunity for you to make a positive, dramatic impact on your community that will be long-lasting and far-reaching. Ambitious? Perhaps, but can you imagine any better way you can influence the future?

Light pollution and light trespass are two subtle but pervasive problems that degrade our quality of life and destroy our enjoyment of the night skies. Too many amateur astronomers have silently witnessed the unnecessary destruction of the night, first beginning in the cities, but now spreading to the remaining rural areas. We must not choose to ignore this problem.

This program is one of personal enlightenment and public awareness. It is divided into twenty activities spread across several categories that teach individuals how light pollution affects them personally and how it affects our society as a whole. Take the challenge at *tinyurl.com/darkskyadvocate*. Confront light pollution!

—John Goss

ALTERNATE CONSTELLATIONS OBSERVING PROGRAM – EXPLORE THE SKY IN A NEW WAY

The Alternate Constellations Observing Program offers the chance to explore star groups as seen from around the globe and across 5,000 years of history. Using just your eyes or small binoculars, the program includes 50 observations of star groups from the cultures of six geographic regions. You also track down 40 obsolete constellations: these were invented beginning in the Renaissance but were discarded when the 88 official constellations were set. A set of additional