

## **Why do Massive (and not-so-Massive) Stars Form? Fundamental data from the *Zooniverse Milky Way Project* Study**

ST. LOUIS—June 12, 2019—The *Milky Way Project: Probing Star Formation with a New Yellowball Catalog* presents a study of 518 infant star-forming regions known as “Yellowballs,” drawn from a catalog made possible by the efforts of citizen scientists. The *Milky Way Project* is one of roughly 100 research initiatives in *Zooniverse*, the world’s largest online platform for citizen science. During 2016-2017, citizen scientists identified more than 6,000 Yellowballs (YBs), which were named for their appearance in *Spitzer Space Telescope* images. A major result of the new study is that YBs provide “snapshots” in time of nascent star-forming regions spanning an enormous range of mass and luminosity.

When the *Milky Way Project* was first launched, it didn’t include searching for YBs – They were added as principal targets only after they were discovered serendipitously by citizen scientists. The color and appearance of YBs come from the way the infrared wavelengths are represented in the *Spitzer* images and the compact sizes of these objects. The infrared images use different colors to represent wavelengths that are invisible to the human eye. Complex organic molecules known as Polycyclic Aromatic Hydrocarbons (or PAHs) show up as green in the images, and very small dust particles as red—where the two overlap completely, you get yellow. YBs are larger than our Solar System, but most are considerably smaller than the typical distance between stars, and yet some of them may eventually produce thousands of stars.

The new catalog contains the positions and sizes of YBs across a large swath of the Milky Way, including regions toward the inner and outer parts of our Galaxy, where stars form under different conditions. The researchers chose a sample of YBs located in a well-studied region of the Milky Way in order to compare the sample with other catalogued indicators of star formation. Their pilot study enabled them to compute distances to the YBs, determine their physical properties, and ascertain that many of these young star-forming regions were missed by other large surveys.

“YBs are helping us investigate a critical but hitherto elusive question: how do the properties of

stars depend upon the properties of the cold, dusty clouds in which stars form?” said Dr. Grace Wolf-Chase Adler Planetarium Astronomer and one of the study’s authors. The reason this question has been elusive is because, once formed, young stars produce winds and radiation that quickly destroy their birth environments.

The fact that most stars form in close company with many other stars complicates the picture even further. “The trick is to catch these newborn star clusters before they ‘clear house,’” said co-author Dr. Charles Kerton, Associate Professor of Astronomy at Iowa State University.

Some YBs are producing very massive stars—the kind of stars that eventually explode as supernovae and enrich their surroundings with heavy elements—while others aren’t. Understanding how the environments that produce massive stars differ from those that don’t is a key unresolved and important question, since massive stars are critical to the production and distribution of heavy elements. In fact, our Solar System is thought to have formed in the company of massive stars, so YBs may tell us a lot about the conditions that led to our own origins.

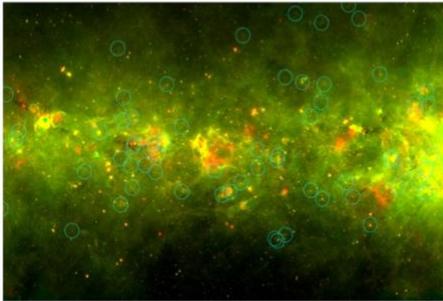
*Zooniverse* is a non-profit collaboration led by the Adler Planetarium and University of Oxford. It has engaged over 1.7 million citizen scientists around the world, and has resulted in more than 200 research publications. The authors are determined to make full use of the YB catalog provided by the citizen scientists working on the *Milky Way Project*, and the next steps are clear. Co-author Kathryn Devine, Associate Professor of Physics at The College of Idaho, said, “We have been working with several talented undergraduate students, who are helping us automate and apply our analysis procedures to the entire YB catalog, so we can explore how stars develop in different environments across our Galaxy.”

Additional co-authors of the *Milky Way Project: Probing Star Formation with a New Yellowball Catalog* include The College of Idaho students Johanna Mori, Leonardo Trujillo, and Sarah Schoultz; Tharindu Jayasinghe, former student at Cal Poly Pomona and current graduate student at The Ohio State University; and Matthew Povich, Associate Professor of Physics and Astronomy at Cal Poly University, Pomona. This research has been made possible in part through Dr. Wolf-Chase’s Illinois Space Grant Consortium Research Seed Grant. Dr. Devine and College of Idaho undergraduates were supported by grant money from the M. J. Murdock Charitable Trust.

### **About the Adler Planetarium**

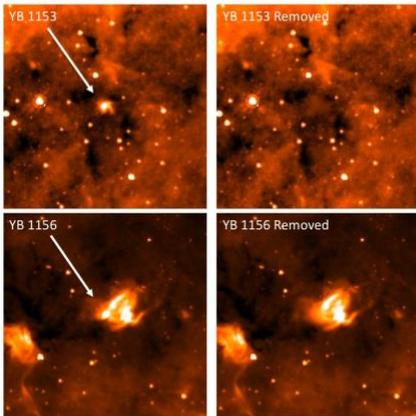
The Adler Planetarium connects people to the Universe and each other. Whether it is introducing a guest to the Ring Nebula, a neighborhood school to a community partner, a research team to a network of citizen scientists, or one staff member to another, the Adler's focus on meaningful connections dates back nearly a century.

Today, the museum hosts more than half a million visitors each year and reaches millions more through youth STEM programs, neighborhood skywatching events, online citizen science, and other outreach projects. With the Adler's support, people of all ages, backgrounds, and abilities gain the confidence to explore their Universe together and return to their communities ready to think critically and creatively about any challenge that comes their way.



New-Star-Forming-RegionsV2.jpg: This image shows a 3 X 2 swath of the Milky Way. It assigns the colors green and red to two of the infrared wavelengths used in the Milky Way Project that highlight complex molecules and dust in our Galaxy. Yellowballs are compact features that are prominent at these wavelengths. Circled yellowballs are associated with cold, dusty clouds, but were missed by other surveys for massive star formation. These yellowballs may be regions producing less massive stars, which will give us a more complete picture of how different types of stars form.

Photo Credit: Charles Kerton, Iowa State University / NASA / Spitzer



StudentWork-for-press-release.jpg: The two left panels highlight yellowballs found in different environments – YB 1153 is relatively isolated from other bright objects, while YB 1156 is not. In order to figure out how much infrared light is coming from the yellowballs, light coming from the background must be subtracted. The two right panels show the background with the yellowballs removed. Undergraduate students at The College of Idaho are working with the researchers to automate this procedure for isolating yellowballs from their complex background environments by creating a GUI and catalog interface that will make the process tractable for the entire catalog.

Photo Credit: Charles Kerton, Iowa State University / NASA / Spitzer