Introduction
The Milky Way Project (MWP) is a citizen-science initiative launched on the Zooniverse platform in 2010. MWP users make “classifications” using a variety of drawing tools to help scientists identify astrophysical phenomena in 3-color infrared (IR) images from the Spitzer Space Telescope.

Citizen scientists catalogued 10x more bubbles than previously found by the pros
Prior to the MWP, visual inspection of Spitzer GLIMPSE survey images by a small team of researchers led to catalogs listing 501 bubbles (Churchwell et al. 2006, 2007). MWP volunteers catalogued 5,106 bubbles within the GLIMPSE survey area (DR1; Simpson et al. 2012), marking an order of magnitude increase over previous catalogs.

The MWP at a glance
35,000+ REGISTERED USERS
3M+ TOTAL CLASSIFICATIONS
8,000+ ONLINE DISCUSSIONS

Bubbles as tracers of star formation
The IR morphology of H II regions is often complicated. These regions require a massive star or star cluster with enough UV area (DR1; Simpson et al. 2012), marking an order of magnitude increase over previous catalogs.

Classifying objects in the MWP
MWP volunteers are guided to identify objects of interest (bubbles, bow shocks, yellowballs, etc.) in a given image and are presented with a list of classification tools (Figure 1). These tools are easy to use and can be adjusted to fit the different object morphologies encountered in the MWP data.

Bow shocks and “Yellowballs” in the MWP
Bow shocks appear as compact 24 µm arcs and are typically associated with OB stars (Kobulnicky et al. 2016). Yellowballs are thought to be a mix of compact and ultra-compact H II regions + similar regions ionized by less powerful B stars (Kerton et al. 2015).

Creating a DR2 bubble catalog
The MWP “Phoenix” data reduction pipeline aggregates classification data using a density-based clustering algorithm that finds associations of similar drawings. Clustered drawings are averaged to produce a catalog of MWP objects. An illustration of this aggregation process for bubbles is shown below in Figure 2.

Comparisons with the MWP DR1 catalog


DR2 bubbles better represent H II regions found by MWP volunteers
- 38% of DR2 bubbles matched DR1 bubbles (GLIMPSE survey area)
- 65% of these matched DR2 bubbles had a smaller geometric mean radius for the “inner” bubble rim (Figure 3)
- DR2 bubbles were ~25% smaller than the corresponding DR1 bubbles.
- DR2 bubbles systematically had a higher eccentricity (Figure 3)
This change can be attributed to the following:
- Improved accuracy in the MWP drawing tools (ellipses in DR2 vs elliptical annuli in DR1).
- Images that are more “zoomed in” than those used previously, enables small objects to be easily classified.
MWP images classified during 2012-2015 did not include MIPS 24 µm data (Figure 2).

Results and next steps
New catalogs – Finalizing the Spitzer search
- Produced DR2 alpha catalog of ~4000 bubbles using unraveled MWP classifications from 2012-2015.
- Further refinements will be made with new data from 2016-2017 to produce a final Spitzer DR2 bubble catalog.
- The first citizen-science bow shock catalog will be published alongside the DR2 bubble catalog. Bubbles and bow shocks will be self-consistently correlated within the MWP database (see poster 340.09 by Dixon et al.).

Improved Catalog properties – Emphasizes reliability
- Reliability scores will be assigned to each MWP bubble based on user weighting, matches between different MWP searches, and “hit rate” (fraction of users who identified the bubble in a given image).
- Uncertainties in central coordinates, semi-major and semi-minor axes, and orientation angle for each bubble will be reported based on dispersions between classifications.

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