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Searching for Erupting Dwarf Novae in the LMC

Michael Shara*
Dept. of Astrophysics
American Museum of Natural History
New York City
E-mail: mshara@amnh.org

David Zurek
Dept. of Astrophysics
American Museum of Natural History
New York City
E-mail: dzurek@amnh.org

Dozens of classical novae have been detected in the Magellanic Clouds over the past century, demonstrating that hundreds of thousands of all kinds of cataclysmic variables must exist in these nearby galaxies. Except for our brief survey 20 years ago, no searches for erupting DWARF NOVAE have been reported in the LMC and SMC. This is a progress report on a search for such eruptions using SALT and SALTICAM.

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*Speaker.

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Motivation and Method

The study of cataclysmic variables (CVs) in our Galaxy is plagued by the same problem that afflicts so many other areas of astrophysics: uncertainty in the distances to, and hence luminosities of, the objects being studied. A second and no less severe problem is the space density and spatial distribution uncertainties caused by our parochial view of the Milky Way. While we can detect erupting Galactic classical novae several kiloparsecs from the Sun, most other known CVs are located closer than about 500 pc. The reason is simple: novae often achieve 100,000 Lsun, rivaling the most luminous objects in our Galaxy for weeks at a time, while dwarf novae (DNe), nova-like variables, and their magnetic cousins rarely exceed 10 - 100 Lsun. Astronomers have succeeded in cataloging barely a thousand Galactic CVs in over a century of searching. Only for a handful are ironclad distances published from Hubble Space Telescope parallaxes. Expansion parallaxes for classical novae contribute another 20 or so reasonably secure distances and luminosities.

It would clearly be of enormous benefit to CV science if hundreds or thousands of CVs, all at the same distance, could be located. Accurate luminosity functions and bias-free period distributions and eruption frequencies would become available to confront inadequately constrained theoretical models. New subclasses of CVs might be discovered and systematic variations in outburst properties and binary orbital distributions would likely be uncovered.

The outlook is promising in the Magellanic Clouds. All CVs discovered in the Clouds are at nearly the same distance, so direct luminosity comparisons are meaningful. Spatial densities of field LMC and SMC stars are roughly comparable to those in the neighborhood of the Sun, rather than those typical of globular cluster cores, so tidal encounters almost never happen. CVs in the Clouds must form and evolve via ordinary binary evolution, just as in the field in our own Galaxy. It is certainly true that the metallicities of the red dwarf companions to the white dwarfs in Magellanic CVs will usually be lower - sometimes much lower - than those in the Galaxy. Lower metallicity is a much less drastic effect than dynamical interactions in globular clusters, so direct comparisons between Galactic and Magellanic CVs should be extremely fruitful. Finally, the Clouds must be home to a Million or more CVs (see below), an enormous sample likely to contain every subtype of CV we know, and perhaps some that we do not yet recognize.

Before carrying out Galaxy - LMC population comparisons, we must, of course, find CVs in the Clouds. Since 1897 about 3 dozen erupting classical novae have been spotted in the LMC and SMC. The current sample of quiescent Magellanic Cloud classical novae is important to follow-up but will grow in number only very slowly. This is because all classical novae must recur with inter-eruption times of thousands of years. Thus, the many thousands of classical novae that exist in the Clouds will only slowly reveal themselves via eruptions over many millennia.

As DNe - a substantial subpopulation of CVs - reveal themselves through out-bursts every few weeks to months, almost all DNe in any given field should be identifiable, at least in principle, in a deep survey of order 6 - 12 months in length. Luminous erupting DNe should achieve u = 22.0, g = 22.5 magnitude near maximum and thus are detectable except in the most crowded LMC fields.

Surveying the entire LMC and SMC often enough to find nearly all erupting DNe is a daunting observational program that can and will eventually be undertaken. A much more modest but realistic feasibility study to demonstrate the existence of erupting DNe in the LMC is the goal of our work with SALT and SALTICAM.

Space density estimates of CVs near the Sun, and of all types of stars in the solar neighborhood yield 0.1 stars per cubic parsec, suggesting that about one CV exists in the Galaxy and probably in the LMC for every 10,000 stars. The LMC displays a V-band luminosity of -18.1, corresponding to a population of order 10 Billion stars. If the Galaxy and LMC manufacture CVs with similar efficiencies and rates, then we estimate a total LMC CV population today of a few Million objects. About half of known CVs are DNe, which suggests a total LMC DN population of order 1 Million. These DNe are spread across the 10 x 10 degree surface of the LMC. Erupting classical novae are observed to be distributed quite uniformly across the face of the LMC, consistent with them belonging to an old population. A surface density of 10,000 DNe per square degree across the LMC is thus expected. SALTICAM covers 0.018 square degrees, which should include 0.018 x 10,000 = 180 DNe. The average time between eruptions for 21 well-studied Galactic DNe is 29 days (Szkody and Mattei 1984, PASP 96, 988) , so the length of our proposed observing run (30 nights spaced over roughly 100 nights, allowing for bright moon/clouds/skipped nights) suggests that a significant fraction of the DN in our field of view - of order 100 - should erupt once or twice during the observing season.

We are observing each field in u and g filters with a gap of 3 or more nights between epochs. This is to ensure dense enough coverage to capture most erupting DN (which remain near maximum for 3-8 nights). DNe are remarkably blue (u - g = -1 mag), so the appearance (and disappearance) of extremely blue objects with maximum brightness u = 21.5 and g = 22.5 mag will be a near-certain detection of LMC DNe. Four good epochs of observations during 2014 demonstrate that we can produce excellent images with SALTICAM (see figures below); and that a much more extensive observing campaign, using all of AMNH P1 and P2 time, as well as a matching contribution of S. African time in 2015/2016, are essential to make this program succeed.

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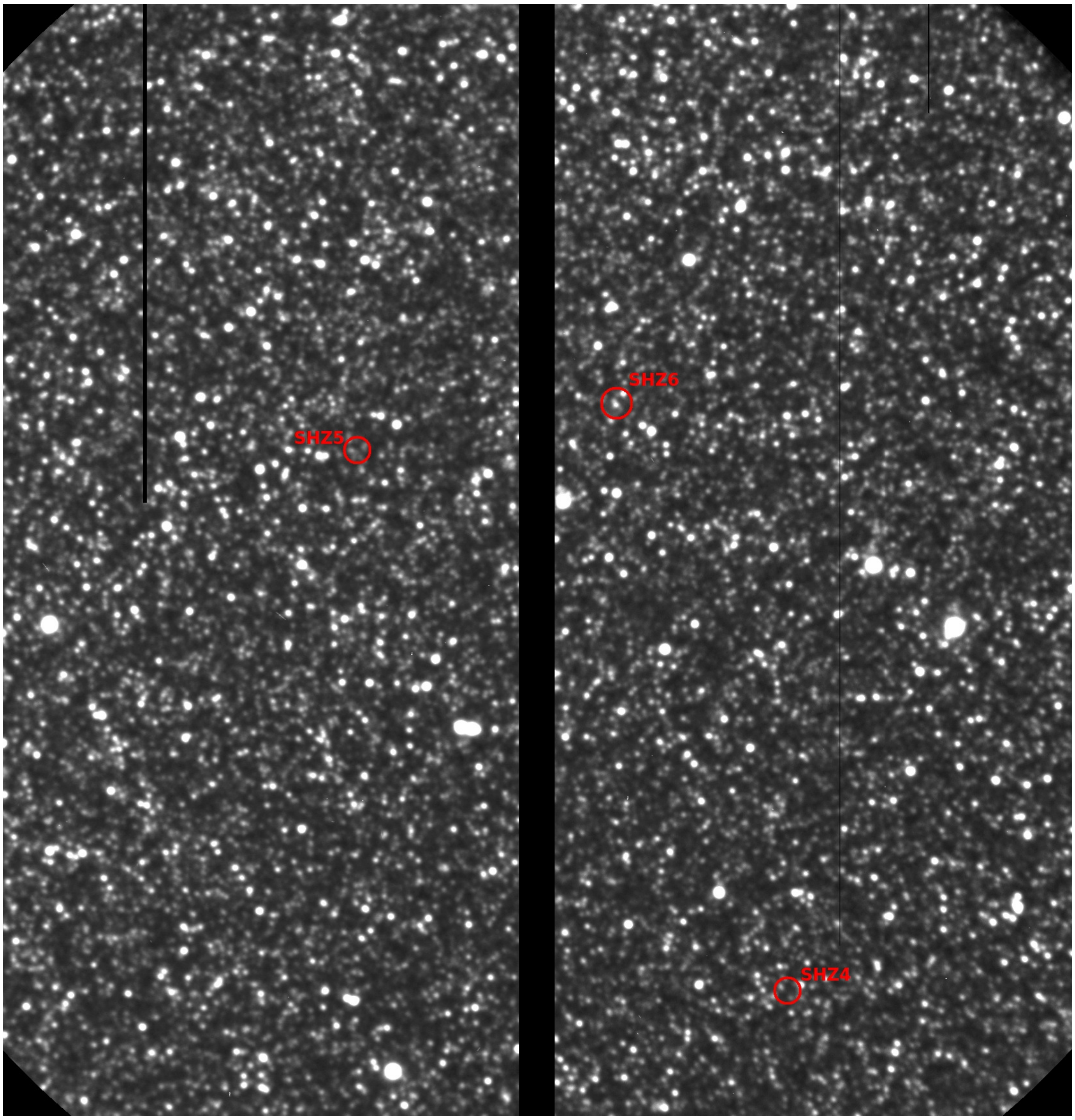

Figure 1: The 8 arcmin, g-band Field of View of SALTICAM, including three suspected DNe in the LMC

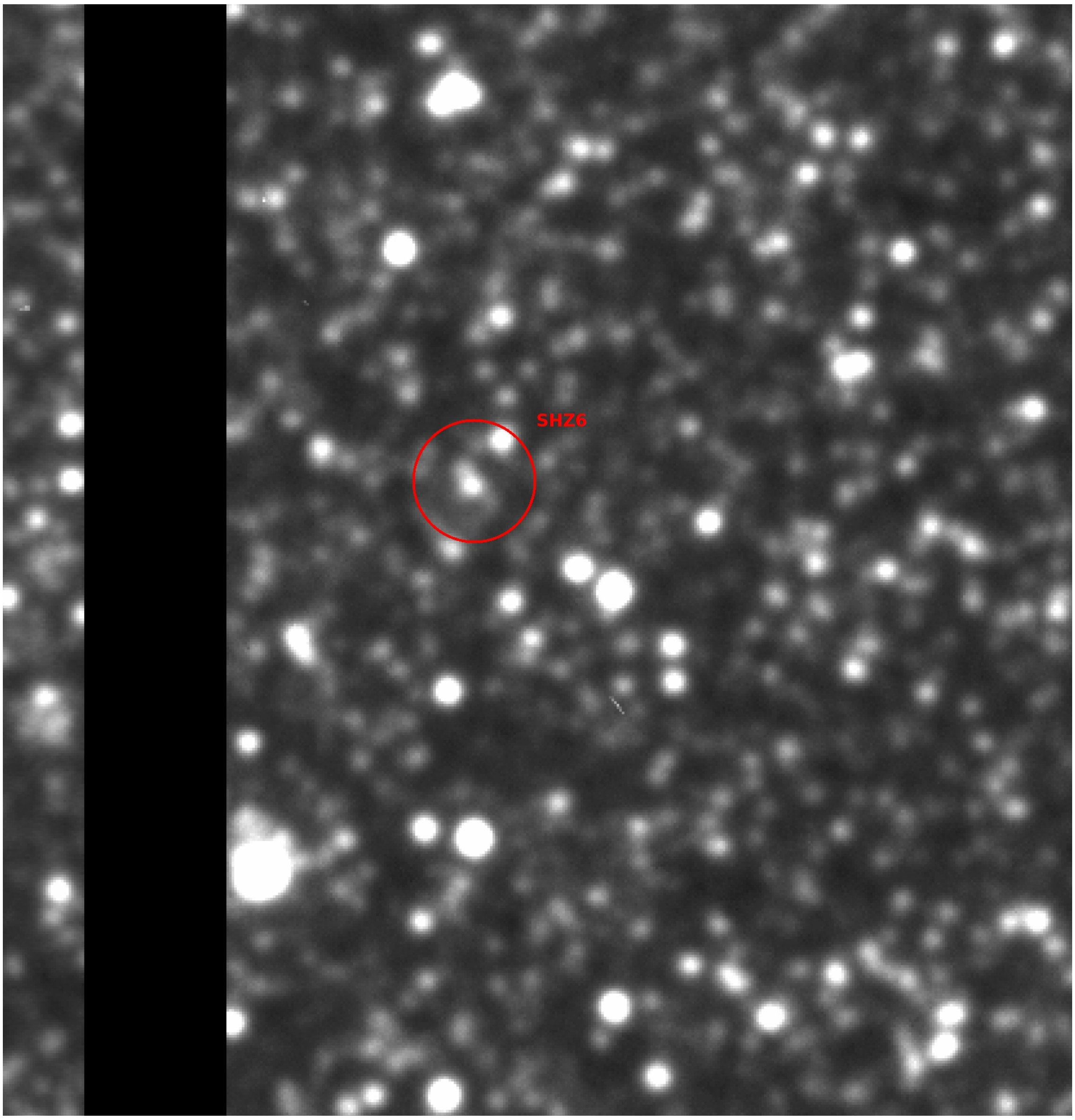

Figure 2: A closeup of one of the DN candidates