2014

[Sabbatical Report]

Louis-Gregory Strolger
Western Kentucky University, louis.strolger@wku.edu

AY2014 Sabbatical Report

Dr. Louis-Gregory Strolger
Physics and Astronomy

07/29/2014

I spent my AY2014 sabbatical year at the Space Telescope Science Institute (STScI), with plans of completing the analyses of supernova rates for both thermonuclear and core-colllape events in high redshift galaxies from the Multi-cycle Treasury Projects with the Hubble Space Telescope. These are projects of extremely high profile, for which I have been a principal collaborator for over 4 years. With the data-collection phase completed for both projects in Fall 2013, STScI was a natural place to work alongside co-investigators to complete these analyses, and begin the next phase of the this research with the Frontier Fields Treasury Survey, which started Dec 2013 and will continue through 2016. It was also an opportunity to compete the assessment of the system response for the RCT 1.3-meter, critical to current and future partners who make use of this telescope.

Results of Primary Goals

- SNIa Rates, CANDELS+CLASH
- CCSN Rate, CANDELS+CLASH
- Photometric Calibration of the RCT 1.3-meter

I contributed analysis to two papers on the type Ia supernova (SNIa) rate at high redshifts: Graur et al. 2014 and Rodney et al. 2014, which reported on the SNIa from the CLASH and CANDELS surveys, respectively. For both, I refined the photometric identification of known candidates, given the full photometric data set to construct the best template images (those without supernova light), and thus the best multi-color light curves from the thorough image subtractions. These light curves were fed to a Bayesian photometric identification algorithm to quantify identifications, however, as this routine was still in development, we relied on my expertise to guide the photometric identifications. The major results of both papers were that the SNIa rate continues to be in deficit at redshifts above 1.2, as first reported in by our team in Strolger et. al 2004 and Dahlen et al. 2004, and still at odds with prompt models for type Ia supernova progenitors. The implications

of this result remain controversial, but support the use of SNIa as robust probes of dark energy over cosmic time.

I have taken the lead on the core-collapse supernova (CCSN) rates from both surveys. The key was a fully refined Bayesian photometric identification algorithm, more critical to event identity than simple a rejection of a SNIa likelihood. The expected results are an independent measure of the star formation rate density to redshift, which I expect to submit for publication in early Fall 2014.

The RCT 1.3-meter telescope is now fully operational, and I took the opportunity to reduce and analyze thousands of images on photometric standards in the RCT archive to derive the broadband photometric calibration for the telescope, which are presented in Strolger et al. 2014. These provide crucial system responses and calibrations to the Vega system for any observations taken with the RCT– important to all partners involved in the RCT Consortium or to anyone who make use of data from this telescope.

Other Outcomes

- Frontier Fields Supernova Search, and Lensed Supernovae
- Morphology of SN Host Galaxies
- The Hubble Legacy Archive, PANSTARRS, and Transients in Archival Data

I also made use of my sabbatical time to forward plans for the continuation of the projects discussed above. The CLASH survey, which targeted clusters of galaxies, had the unique capacity to identify background supernovae magnified in the gravitational lens provided by the cluster mass (we reported on the discovery of a few with CLASH in Patel et al. 2014). This opened up a new "frontier" in distant supernova searches, one in which we could find events we would otherwise be insensitive to, and possibly test precision cosmology (particularly H_0 to within 10%) if the circumstances of geometry were favorable. This opportunity presented itself in December 2013 with a new initiative, the Frontier Fields survey, the goal of which is locating the universe's earliest galaxies using foreground clusters of galaxies as "natural telescopes", amplifying the light just enough to enable their detection. The Frontier Fields Supernova Search, a piggy-back program I am a part of, uses these clusters for the similar ends, and is expected to improve our measure of the high-z supernova rates by 20%.

We now have a sample of 200+ supernovae from the HST SN surveys, spanning over a decade of near continuous use with HST. The sample now seems sufficient to exploring the properties of supernova host galaxies in comparison to their counterparts at much lower redshift. My plan is to recruit a WKU student in the principal analysis of the sample, collaborating with experts in galaxy morphologies and their interpretation at high-z at STScI. This work should begin in Fall 2014. I plan to seek funding for this study through NASA KY and internal funding opportunities at WKU and STScI.

There are two highly anticipated public archives coming on-line at STScI– the Hubble Legacy Archive, and the 1st campaign of PANSTARRS (PS1). Both have frequent revisits of several fields, one from continuous coverage of 3/4 of the entire sky, and the other from sparser but deeper coverage over the entire sky. Naturally, these revisits have resulted in numerous previously unknown stellar variables and other transients, which are generally bright ($R > 20$) and completely uncharacterized. The newly available RCT 1.3-meter is ideal for collecting light curves for a large number of these variable/transients, sampling at on a variety of time-scales for adequate phase diagrams across the range of variability from white dwarfs to Wolf-Rayet stars. A goal for this program would be to better quantify the spacial density (and total number) of cataclysmic variables (particularly super-soft X-ray sources) to evaluate the likelihood of these systems as progenitors of type Ia supernovae. I plan to seek funding to enable this program through the NSF AAG in Fall 2014.

Publications Durring Sabbatical

• **Strolger, L.-G.**, Gott, A. M., Carini, M., Engle, S., Gelderman, R., Guinan, E., Laney, C. D., McGruder, C., Treffers, R. R., & Walter, D. K. 2014, "The RCT 1.3 m Robotic Telescope: Broadband Color Transformation and Extinction Calibration", The Astronomical Journal, 147, 49

• Rodney, S. A., Riess, A. G., **Strolger, L.-G.**, Dahlen, T., Graur, O., Casertano, S., Dickinson, M. E., Ferguson, H. C., Garnavich, P., Hayden, B., Jha, S. W., Jones, D. O., Kirshner, R. P., Koekemoer, A. M., McCully, C., Mobasher, B., Patel, B., Weiner, B. J., Cenko, S. B., Clubb, K. I., Cooper, M., Filippenko, A. V., Frederiksen, T. F., Hjorth, J., Leibundgut, B., Matheson, T., Nayyeri, H., Penner, K., Trump, J., Silverman, J. M., U, V., Azalee Bostroem, K., Challis, P., Rajan, A., Wolff, S., Faber, S. M., Grogin, N. A., & Kocevski, D. 2014, "Type Ia Supernova Rate Measurements to Redshift 2.5 from CANDELS: Searching for Prompt Explosions in the Early Universe", The Astronomical Journal, 148, 13

• Graur, O., Rodney, S. A., Maoz, D., Riess, A. G., Jha, S. W., Postman, M., Dahlen, T., Holoien, T. W.-S., McCully, C., Patel, B., **Strolger, L.-G.**, Benítez, N., Coe, D., Jouvel, S., Medezinski, E., Molino, A., Nonino, M., Bradley, L., Koekemoer, A., Balestra, I., Cenko, S. B., Clubb, K. I., Dickinson, M. E., Filippenko, A. V., Frederiksen, T. F., Garnavich, P., Hjorth, J., Jones, D. O., Leibundgut, B., Matheson, T., Mobasher, B., Rosati, P., Silverman, J. M., U, V., Jedruszczuk, K., Li, C., Lin, K., Mirmelstein, M., Neustadt, J., Ovadia, A., & Rogers, E. H. 2014, "Type-Ia Supernova Rates to Redshift 2.4 from CLASH: The Cluster Lensing And Supernova Survey with Hubble". The Astrophysical Journal, 783, 28

• Patel, B., McCully, C., Jha, S. W., Rodney, S. A., Jones, D. O., Graur, O., Merten, J.,

Zitrin, A., Riess, A. G., Matheson, T., Sako, M., Holoien, T. W.-S., Postman, M., Coe, D., Bartelmann, M., Balestra, I., Benítez, N., Bouwens, R., Bradley, L., Broadhurst, T., Cenko, S. B., Donahue, M., Filippenko, A. V., Ford, H., Garnavich, P., Grillo, C., Infante, L., Jouvel, S., Kelson, D., Koekemoer, A., Lahav, O., Lemze, D., Maoz, D., Medezinski, E., Melchior, P., Meneghetti, M., Molino, A., Moustakas, J., Moustakas, L. A., Nonino, M., Rosati, P., Seitz, S., **Strolger, L. G.**, Umetsu, K., & Zheng, W. 2014, "Three Gravitationally Lensed Supernovae behind CLASH Galaxy Clusters", The Astrophysical Journal, 786, 9

Talks Durring Sabbatical

- Google Hangout, Open Panel, "Early Results From the Frontier Fields Survey", June 2014

- University of Virginia, Colloquium, "High-z Supernovae Beyond the Epoch of Dark Energy", April 2014

- Space Telescope Science Institute, Public Lecture, "Current Results on Cosmology", August 2013