



UNIVERSITY OF
SOUTH CAROLINA

**Proposal to the South Carolina Space Grant Consortium
NASA EPSCoR Research Grant Program (\$25k)**

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Project Title:

Rare and Peculiar Stellar Explosions with the Next Generation of Space Telescopes

NASA Alignment:

- Science Mission Directorate (SMD) - Astrophysics Division

Related NASA Centers:

- Space Telescope Science Institute (Baltimore, MD)
- NASA Goddard Space Flight Center (Greenbelt, MD)
- Infrared Processing and Analysis Center (Pasadena, CA)

Within the next decade, NASA will be operating two new flagship missions for space-based astronomical research. The James Webb Space Telescope (JWST) will launch in 2018, providing a new infrared observatory that will be a powerful successor to the Hubble Space Telescope (HST). In the mid-2020's the Wide Field Infrared Survey Telescope (WFIRST) will add an unprecedented new ability for wide-area sky surveys from space. Both of these telescopes will open up new avenues for the study of stellar explosions (supernovae)—particularly explosions from the very early universe that are currently too distant and too faint for even HST to observe.

With JWST we will be able to see the peculiar supernovae that occurred when the very first generation of stars died. This glimpse at the earliest epoch of star formation (and stellar death) will address fundamental questions about the formation and early evolution of galaxies and stars. Although WFIRST will not reach as deep into the murky past, it will execute wide and fast surveys that will enable detection of rare stellar explosions that occur in unusual places, such as supernovae that happen to lie behind dense dark matter clusters. As sketched in Figure 1, a dense concentration of dark matter between us and the supernova can act as a *gravitational lens*, distorting and focusing the light from the background supernova. By measuring these effects we can learn about the intervening dark matter or the nature of dark energy.

We propose to develop a new open-source software suite to simulate JWST and WFIRST supernova surveys, implementing for the first time a rigorous treatment of both gravitational lensing and the peculiar stellar explosions that are unique to the early universe. We will then use these tools to design and evaluate the first supernova surveys with JWST and WFIRST. These simulations are **necessary** to efficiently allocate telescope resources and to properly account for selection biases that would otherwise skew the interpretation of very distant supernova samples. This work is also **timely**, as our products will be available just in time for use in proposing for JWST observing in 2019, and will be able to influence the ongoing WFIRST mission design. We plan to develop this software in the open, making it instantly and **widely accessible**.

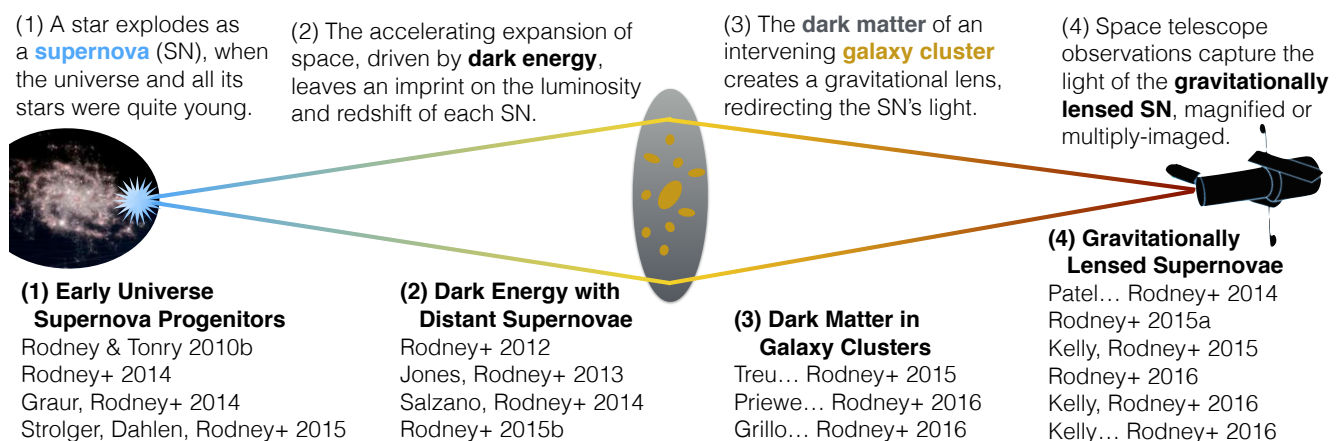


Figure 1: The context of supernova research led by PI Rodney. This proposal would develop new software that is relevant for all four branches of the research program depicted here.

STEVEN A. RODNEY

Biographical Sketch

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Professional Preparation

Case Western Reserve University	Cleveland, OH	Physics	B.S., 2003
Case Western Reserve University	Cleveland, OH	Astronomy	B.S., 2003
Institute for Astronomy, University of Hawai'i at Mānoa	Honolulu, HI	Astronomy	M.S., 2005
Institute for Astronomy, University of Hawai'i at Mānoa	Honolulu, HI	Astronomy	Ph.D., 2010
Johns Hopkins University	Baltimore, MD	Astronomy	2010–2015

Appointments

2015–present	Assistant Professor, University of South Carolina
2012–2015	Hubble Postdoctoral Research Fellow, Johns Hopkins University
2010–2012	Assistant Research Scientist, Johns Hopkins University

Products: Publications Related to the Proposed Project

1. *SN Refsdal: Photometry and Time Delay Measurements of the First Einstein Cross Supernova*
Rodney; Strolger, Kelly, Bradac, Brammer, Filippenko, Foley, Graur, Hjorth, Jha, McCully, Molino, Riess, Schmidt, Selsing, Sharon, Treu, Weiner, and Zitrin 2016, ApJ, 820, 50
2. *Deja Vu All Over Again: The Reappearance of Supernova Refsdal*
Kelly, **Rodney**, Strolger, Foley, Jha, Selsing, Brammer, Bradac, Cenko, Graur, Filippenko, Hjorth, McCully, Molino, Nonino, Riess, Schmidt, Tucker, von der Linden, and Zitrin 2016, ApJ, 819, 8
3. *Illuminating a Dark Lens : A Type Ia Supernova Magnified by the Frontier Fields Galaxy Cluster Abell 2744*
Rodney, Patel, Scolnic, Foley, Molino, Brammer, Jauzac, Bradac, Broadhurst, Coe, Diego, Graur, Hjorth, Hoag, Jha, Johnson, Kelly, Lam, McCully, Medezinski, Meneghetti, Merten, Richard, Riess, Sharon, Strolger, Treu, Wang, Williams, and Zitrin 2015, ApJ, 811, 70;
4. *Multiple Images of a Highly Magnified Supernova Formed by an Early-Type Cluster Galaxy Lens*
Kelly, **Rodney**, Treu, Foley, Brammer, Schmidt, Zitrin, Sonnenfeld, Strolger, Graur, Filippenko, Jha, Riess, Bradac, Weiner, Scolnic, Malkan, von der Linden, Trenti, Hjorth, Gavazzi, Fontana, Merten, McCully, Jones, Postman, Dressler, Patel, Cenko, Graham, and Tucker 2015, Science, 347, 1123
5. *Three Gravitationally Lensed Supernovae behind CLASH Galaxy Clusters*
Patel, McCully, Jha, **Rodney**; Jones, Graur, Merten, Zitrin, Riess, Matheson, Sako, Holoien, Postman, Coe, Bartelmann, Balestra, Benitez, Bouwens, Bradley, Broadhurst, Donahue, Filippenko, Ford, Garnavich, Grillo, Infante, Jovel, Kelson, Koekemoer, Lahav, Lemze, Maoz, Medezinski, Melchior, Meneghetti, Molino, Moustakas, Moustakas, Nonino, Rosati, Seitz, Strolger, Umetsu, and Zheng 2014, ApJ, 786, 9

Products: Other Significant Publications

1. *Two Type Ia Supernovae at $z \sim 2$: Improved Classification and Redshift Determination with Medium-band IR Imaging*
Rodney; Riess, Scolnic, Jones, Hemmati, Molino, McCully, Mobasher, Strolger, Graur, Hayden, and Casertano 2015, AJ, 150, 156
2. *Type Ia Supernova Rate Measurements to Redshift 2.5 from CANDELS: Searching for Prompt Explosions in the Early Universe*
Rodney, Riess, Strolger, Dahlen, Graur, Casertano, Dickinson, Ferguson, Garnavich, Hayden, Jha, Jones, Kirshner, Koekemoer, McCully, Mobasher, Patel, Weiner, Cenko, Clubb, Cooper, Filippenko, Frederiksen, Hjorth, Leibundgut, Matheson, Nayyeri, Penner, Trump, Silverman, U, Azalee Bostroem, Rajan, Wolff, Faber, Grogan, and Kocevski 2014, AJ, 148, 13
3. *Type Ia Supernova Rates to Redshift 2.4 from CLASH: the Cluster Lensing and Supernova Survey with Hubble*
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.; Bentez, 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, ApJ, 783, 28
4. *The Discovery of the Most Distant Known Type Ia Supernova at Redshift 1.914*
Jones, **Rodney**, Riess, Mobasher, Dahlen, McCully, Frederiksen, Casertano, Hjorth, Keeton, Koekemoer, Strolger, Wiklind, Challis, Graur, Hayden, Patel, Weiner, Filippenko, Garnavich, Jha, Kirshner, Ferguson, Grogan, and Kocevski. 2013, ApJ, 768, 166
5. *A Type Ia Supernova at Redshift 1.55 in the Infrared from the CANDELS Hubble Treasury Program*
Rodney, S. A.; Riess, A. G.; Dahlen, T.; Strolger, L.-G.; Ferguson, H. C.; Hjorth, J.; Frederiksen, T. F.; Weiner, B. J.; Mobasher, B.; Casertano, S.; Jones, D. O.; Challis, P.; Faber, S.; Filippenko, A. V.; Garnavich, P.; Graur, O.; Grogan, N. A.; Hayden, B.; Jha, S. W.; Kirshner, R. P.; Kocevski, D.; Koekemoer, A.; McCully, C.; Patel, B.; Rajan, A.; Scarlata, C. 2012, ApJ, 746, 5

Synergistic Activities

Teaching Innovation: PI for a *Course Transformation Program* grant proposal in 2017 to implement peer guided, team-based learning into introductory astronomy courses at USC. Participant and leader for pedagogical communities of practice at USC through the Center for Teaching Excellence.

Community Outreach: Established a new lecture series in physics and astronomy at USC, bringing distinguished speakers to Columbia, SC to deliver science talks to a broad public audience. Spearheading the USC outreach and education efforts for the total solar eclipse of 2017.

Service to Scientific Community: Regularly serving as a reviewer for the Hubble Space Telescope Time Allocation Committee, and referee for *The Astrophysical Journal*, *The Astronomical Journal*, and *Astronomy & Astrophysics*.