An Atlas of Stars Past: Supernova Remnants in the Optical Spectrum

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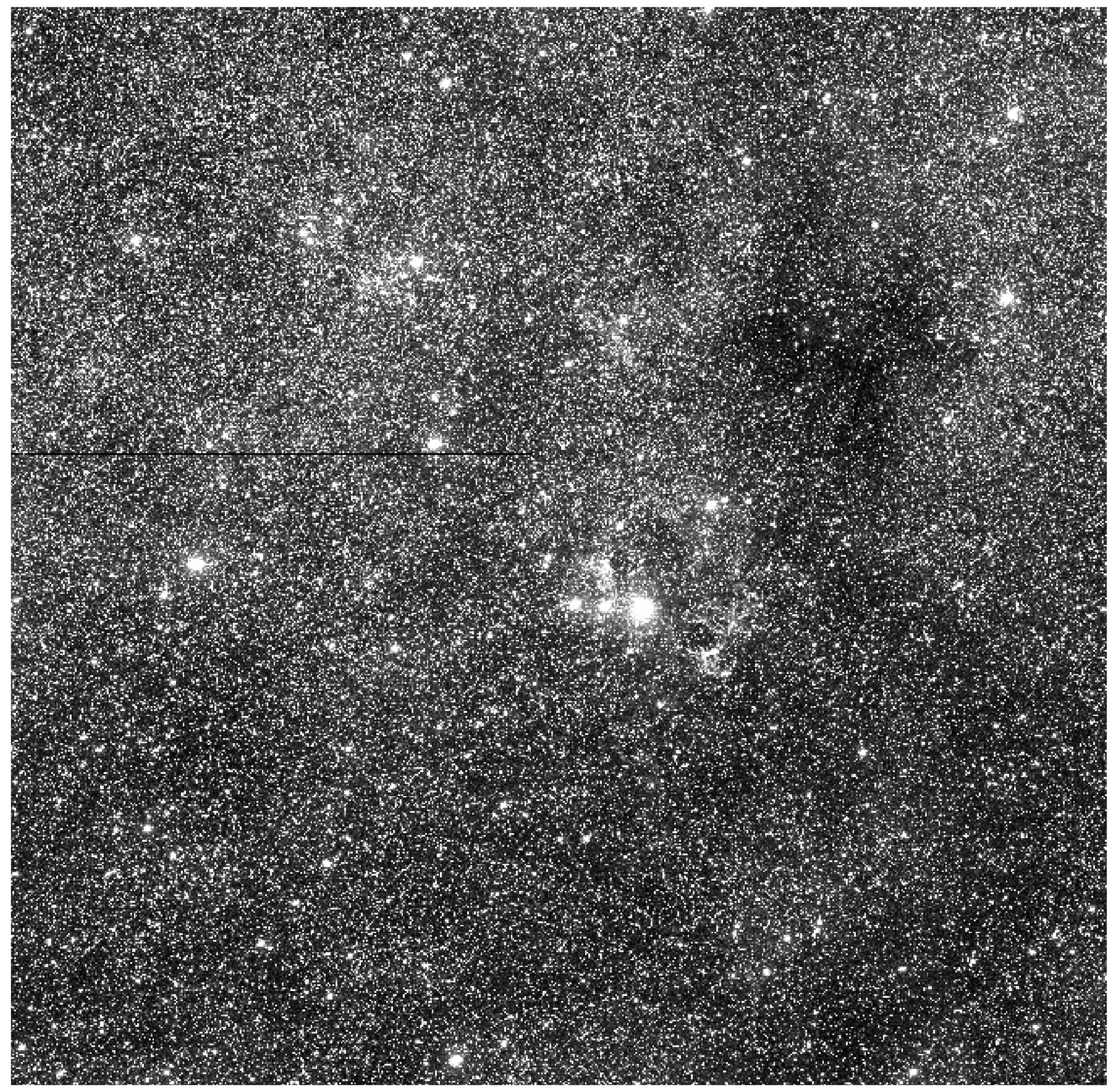
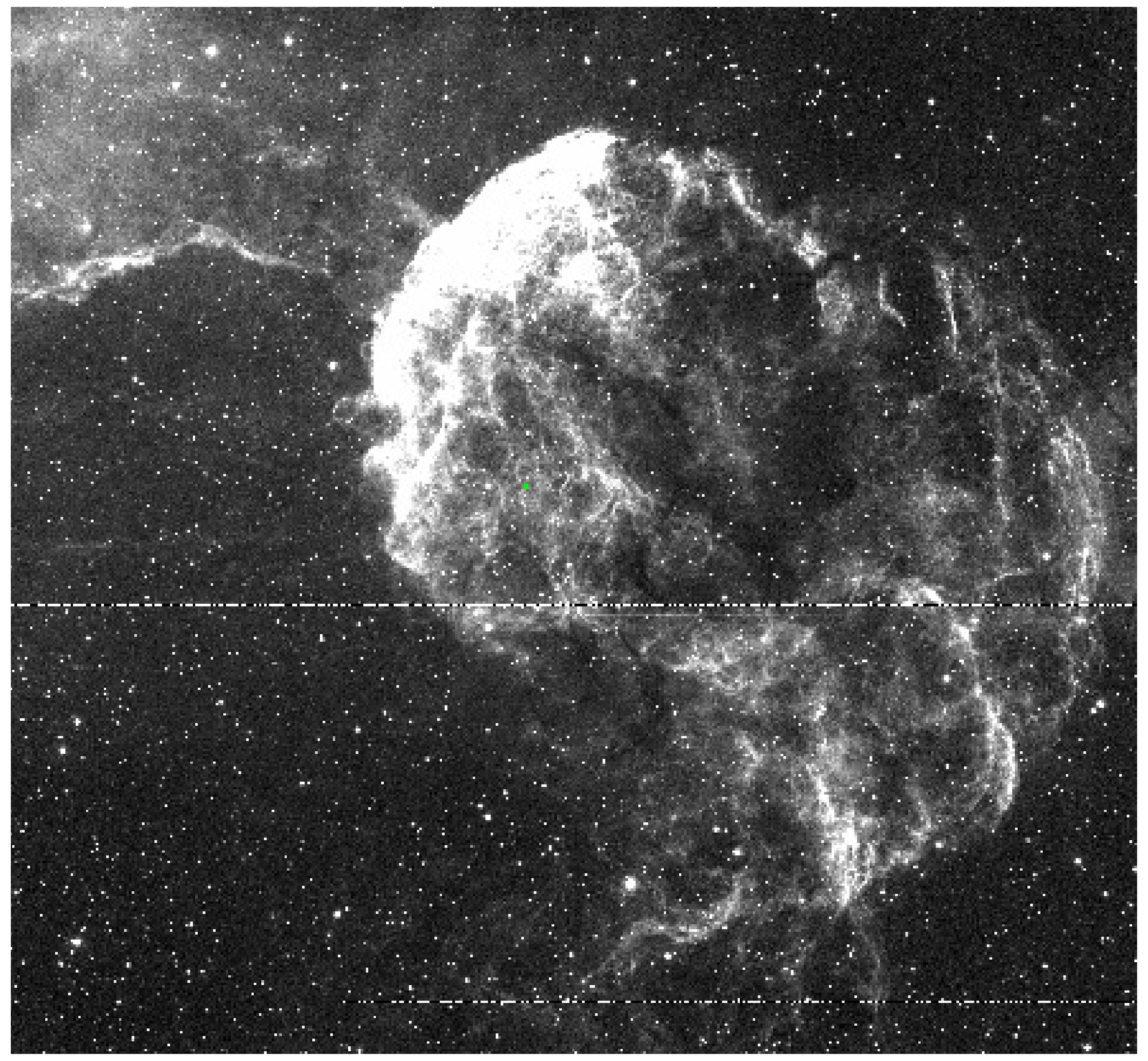
Supernova remnants are the luminous shells of gas produced by the explosive deaths of large stars. They reveal the composition of stars and the interstellar medium, and contribute to our understanding of star life cycles and the evolution of galaxies. In our work, we processed multiple narrow-band image sets of Galactic supernova remnants (SNRs). Using IRAF, we converted the raw data into images ready for analysis and presentation. With our images, we began creating an online SNR atlas to serve as a resource for the greater astronomy community.

Data Collection

In our work, we processed image datasets taken by Prof. Frank Winkler and a succession of Middlebury College students at the 0.9m Schmidt Telescope at the Cerro Tololo Inter-American Observatory in Chile and the 0.9m Schmidt telescope at Kitt Peak National Observatory in Arizona. These optical images of twenty-two SNRs were taken through filters revealing hydrogen-alpha, sulfur, and oxygen emission lines and the red and green continuum bands.

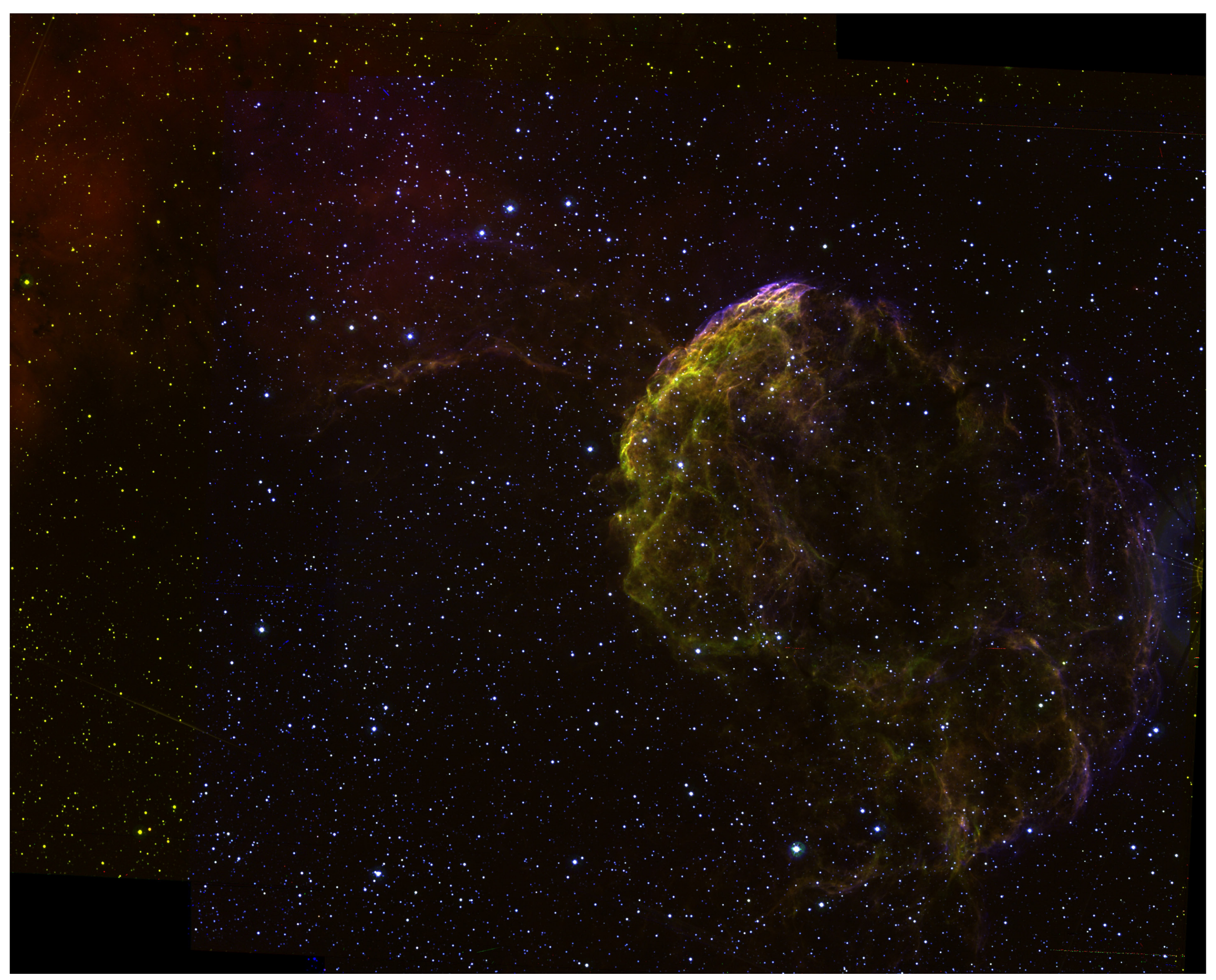




Above: Raw image of G296.1-0.5 in [S II], taken January 28th 2001.
Right: Raw image of IC 443 in hydrogen-alpha, taken June 18th 1996.
To fix imperfections from the charged-coupled device (CCD) in these images, the overscan was fit, subtracted, and trimmed; bias frames and dark frames were subtracted, and the images were scaled by a uniform flat-field frame combined from dusk and dawn flats.

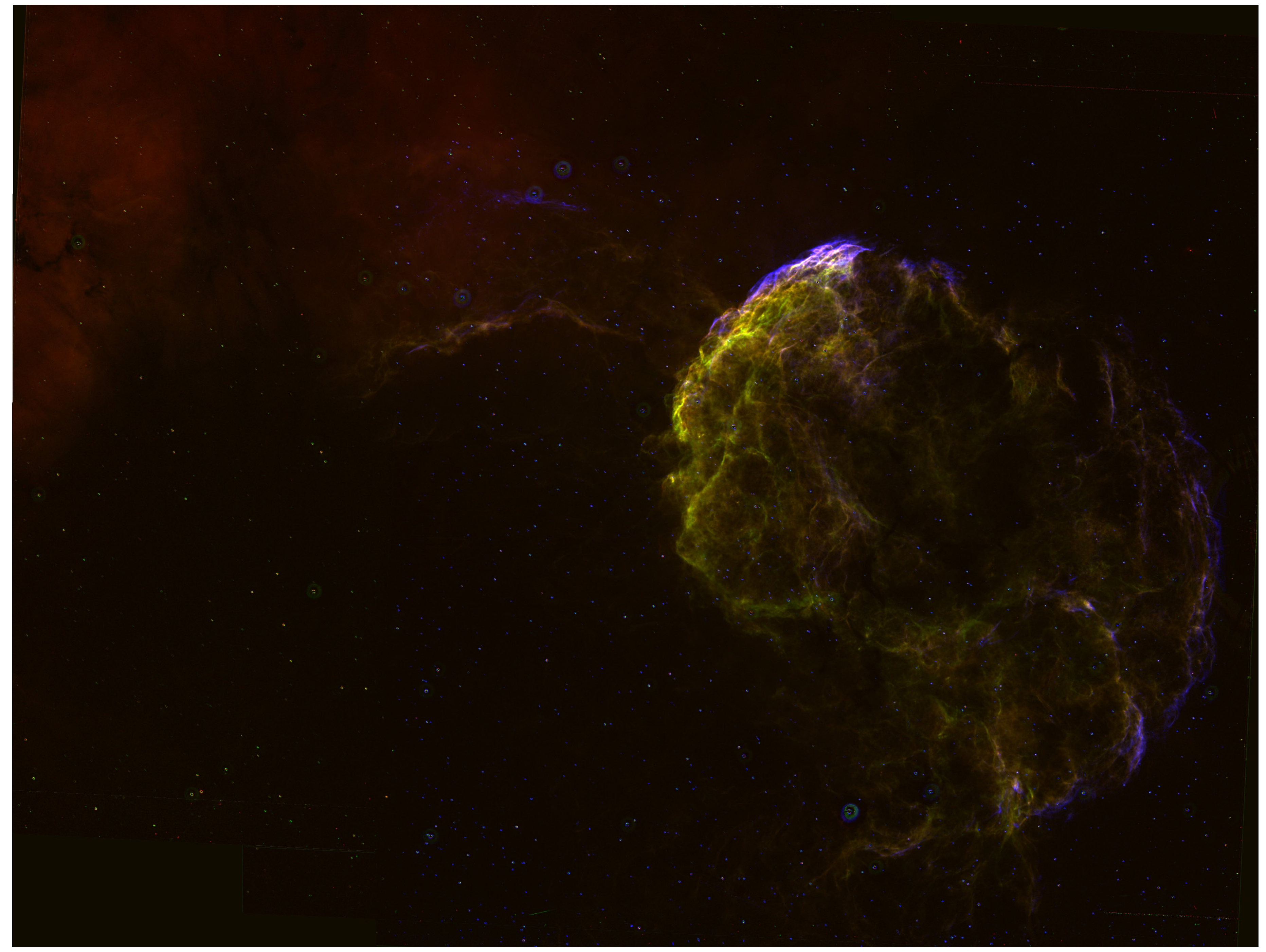
Combined Images

We then assigned a World Coordinate System (WCS) to all original images using star fields from the USNO Integrated Image and Catalogue Archive Service. We applied a tangent plane geometry to match a list of star coordinates to the stars' positions in the images.
Left: Color-combined image of G296.1-0.5, each color representing a stacked emission frame.
Below: Color-combined image of IC 443, stacked similarly.



To combine the images into a single frame per filter, we reprojected each image to a standard canvas at 1 arcsec / pixel, and we stacked the images into a single frame with an algorithm that uses the properties of the CCD chip to selectively exclude outlier pixels. At this point, any imperfections caused by bad pixels on the CCD were accounted for. Each emission frame was then matched in size and WCS to the continuum frame in preparation for subtraction.

Subtracted Images



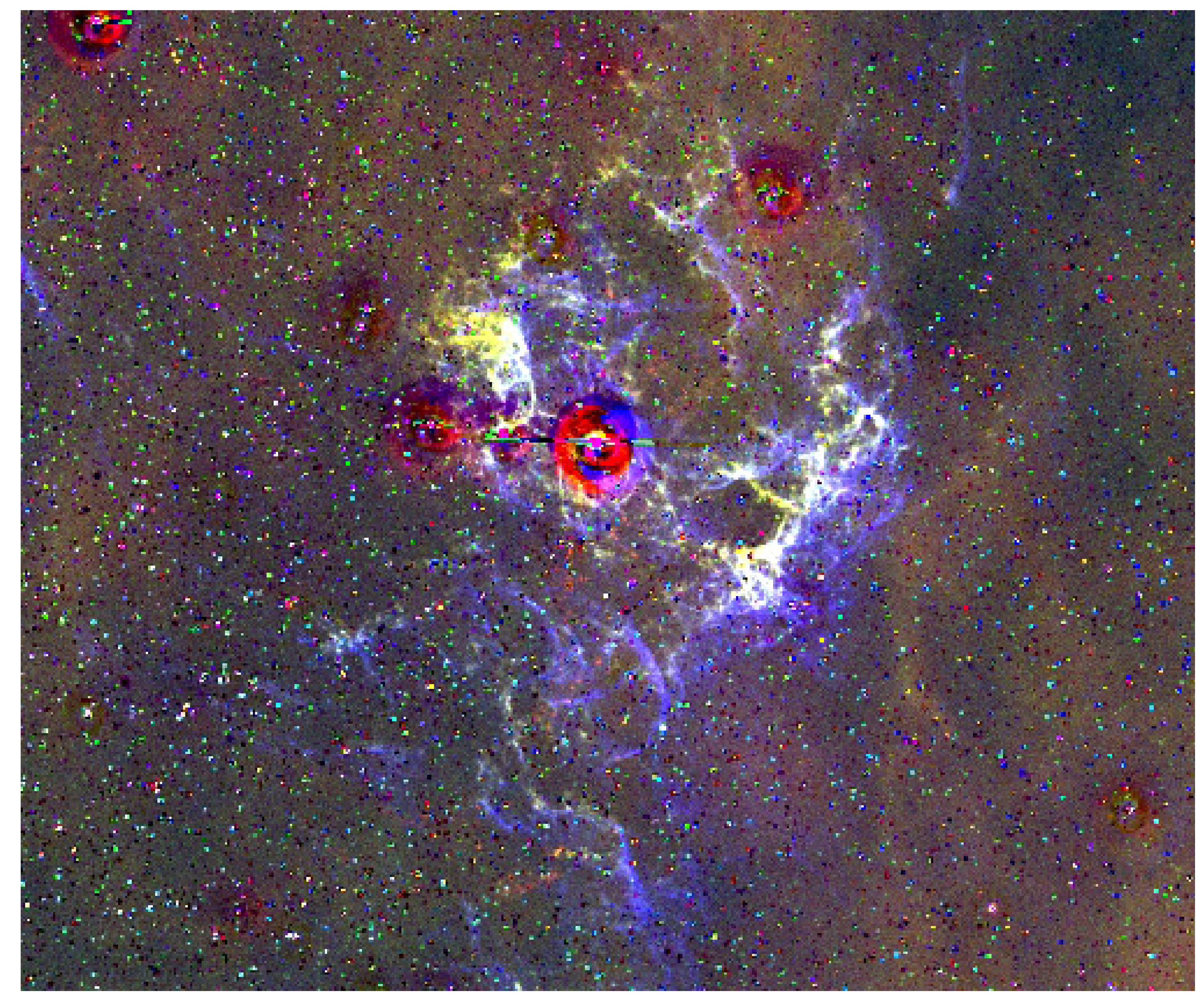
We subtracted color continuum frames from the emission frames to remove the stars. A red frame was subtracted from each combined H-alpha and [S II] image, and a green frame was subtracted from each [O III] image. Both sets of combined and subtracted frames were color-combined in DS9, with H-alpha in red, [S II] in green, and [O III] in blue. We flux-corrected each image to standardize exposure times, read noise, and flux values, and calculated the integrated flux.

The emission lines chosen are significant to classifying SNRs and understanding their chemical characteristics. H-alpha is typically the strongest emission from a SNR; prevalent [SII] emissions distinguish a SNR from more common photo-ionized nebulae; and bright [OIII] emissions indicate the shockwave that created the SNR is moving at over 100 km/s.

Left: IC 443 color-combined with stars subtracted.
Below: G296.1-0.5 color-combined with stars subtracted. The large red circles are artifacts left by bright stars passing through the filter.

Creating an Atlas

In an effort to contribute to future research on SNRs, we have begun making an atlas of SNRs in the optical spectrum. Astronomers will be able to access narrow-band optical images primed for research use, along with images from other surveys in infrared and x-ray to allow for side-by-side emission comparison. The atlas will also serve as an educational resource on SNRs for the public, with multiple false-color composite images and links to other informative catalogues.



SNRs in our atlas

- G005.4-1.2 (Milne 56)
- G006.4-0.1 (W28)
- G013.3-1.3*
- G018.9-1.1*
- G039.7-2.0 (W50)*
- G166.0+4.3 (VRO 42.05.01)
- G189.1+3.0 (IC 443)
- G272.2-3.2
- G292.0+1.8
- G296.1-0.5
- G296.8-0.3
- G299.2-2.9
- G302.3+0.7
- G309.2-0.6
- G320.4-1.0 (RCW 89)*
- G321.9-0.3*
- G326.3-1.8 (MSH 15.56)
- G338.1+0.4*
- G339.2-0.4*
- G341.3-0.5*
- G347.3-0.5*
- G347.5-0.5*

*tentative additions to the atlas

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Want to see more? It's coming soon to **go/snr** !