Asymmetric Planetary Nebulae 5
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Expansion in the Planetary Nebula NGC 6302

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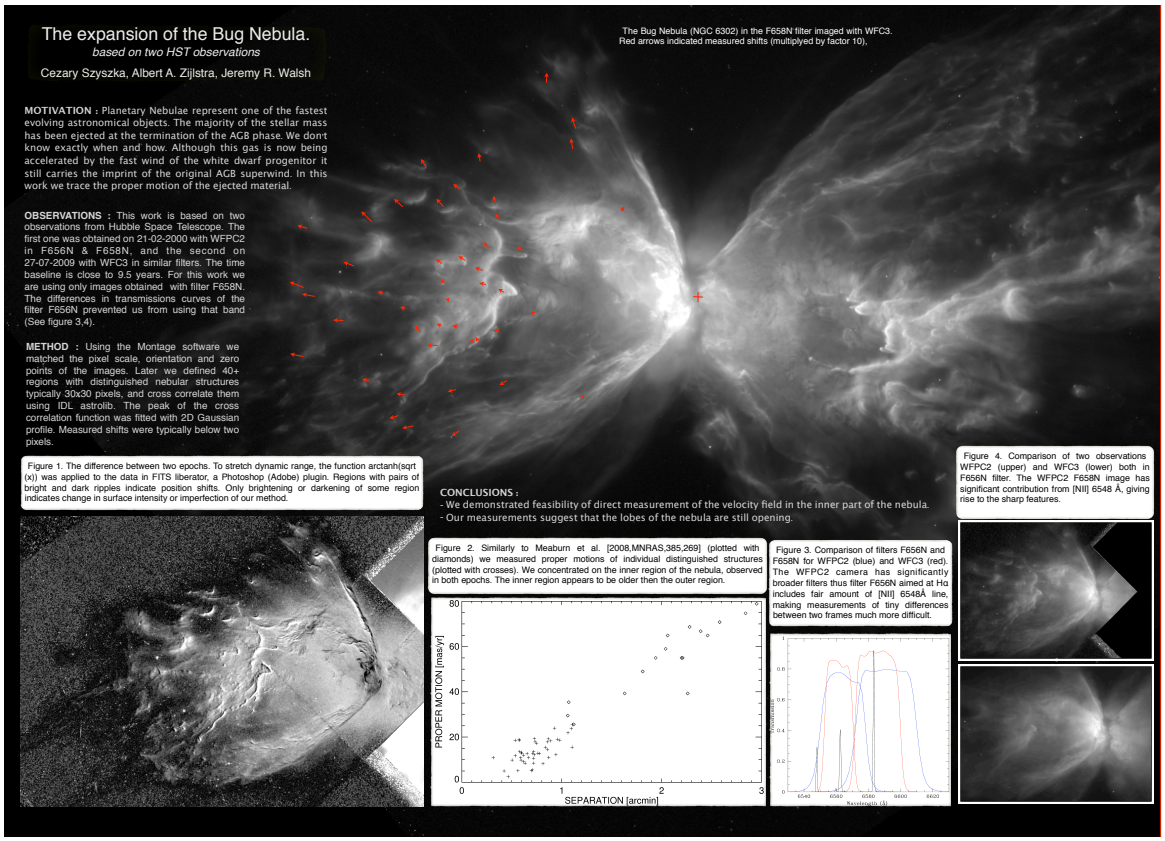
During the final stage of stellar evolution a star ejects its outer envelope, accelerates it, and eventually ionizes it, forming planetary nebula. At this stage the expelled gas shines brightly, often forming distinguishable sub-structures in its earlier outflows. By tracing the expansion of these structures we obtain a direct insight into the velocity field of the planetary nebula. Meaburn et al. (2002) applied the same technique to the outermost parts of NGC 6302, using two observations separated by 50 years. We compared *HST* images of NGC 6302 from two epochs separated by ∼10 years to look for movement of the gas. We present work which attempts to reproduce the velocity field in the innermost regions of NGC 6302.


The expansion of the Bug Nebula.
based on two HST observations
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MOTIVATION : Planetary Nebulae represent one of the fastest evolving astronomical objects. The majority of the stellar mass has been ejected at the termination of the AGB phase. We don't know exactly when and how. Although this gas is now being accelerated by the fast wind of the white dwarf progenitor it still carries the imprint of the original AGB superwind. In this work we trace the proper motion of the ejected material.
OBSERVATIONS : This work is based on two observations from Hubble Space Telescope. The first one was obtained on 21-02-2000 with WFPC2 in F656N & F658N, and the second on 27-07-2009 with WFC3 in similar filters. The time baseline is close to 9.5 years. For this work we are using only images obtained with filter F658N. The differences in transmissions curves of the filter F656N prevented us from using that band (See figure 3,4).
METHOD : Using the Montage software we matched the pixel scale, orientation and zero points of the images. Later we defined 40+ regions with distinguished nebular structures typically 30x30 pixels, and cross correlate them using IDL astrolib. The peak of the cross correlation function was fitted with 2D Gaussian profile. Measured shifts were typically below two pixels.
The Bug Nebula (NGC 6302) in the F658N filter imaged with WFC3.
Red arrows indicated measured shifts (multiplyed by factor 10),
Figure 1. The difference between two epochs. To stretch dynamic range, the function arctanh(sqrt (x)) was applied to the data in FITS liberator, a Photoshop (Adobe) plugin. Regions with pairs of bright and dark ripples indicate position shifts. Only brightening or darkening of some region indicates change in surface intensity or imperfection of our method.
CONCLUSIONS :
- We demonstrated feasibility of direct measurement of the velocity field in the inner part of the nebula.
- Our measurements suggest that the lobes of the nebula are still opening.
Figure 2. Similarly to Meaburn et al. [2008,MNRAS,385,269] (plotted with diamonds) we measured proper motions of individual distinguished structures (plotted with crosses). We concentrated on the inner region of the nebula, observed in both epochs. The inner region appears to be older then the outer region.
PROPER MOTION [mas/yr]
SEPARATION [arcmin]
Figure 3. Comparison of filters F656N and F658N for WFPC2 (blue) and WFC3 (red). The WFPC2 camera has significantly broader filters thus filter F656N aimed at Hα includes fair amount of [NII] 6548Å line, making measurements of tiny differences between two frames much more difficult.
Figure 4. Comparison of two observations WFPC2 (upper) and WFC3 (lower) both in F656N filter. The WFPC2 F658N image has significant contribution from [NII] 6548 Å, giving rise to the sharp features.