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Results of WFC3 Thermal Vacuum Testing - UVIS Channel Ghosts

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ABSTRACT

The optical ghosts in the WFC3 UVIS channel, measured during the Fall 2004 thermal-vacuum test, show the same morphologies and strengths as characterized previously while under ambient conditions. All filters previously showing optical ghosts were tested: F225W, F280N, F606W, F218W, F275W, F300X, F410M, F467M, F547M, F621M, F625M, F689M, F775W, F814W, FQ232N, FQ243N, F656N, F658N, F665N, F673N, and F680N. F225W, F280N, and F606W are representative of all ghost behavior, and were tested at 8 field points; the remaining filters were tested at one field point.

Introduction

The WFC3 UVIS channel shows significant optical ghosts in a subset of its filters. These ghosts are due to reflections from the window and filter surfaces, and are fully described by Brown & Lupie (2004, ISR WFC3-2004-004). Previous tests on the optical performance of these filters, in the assembled instrument, were done under ambient conditions. The Fall 2004 WFC3 thermal-vacuum testing provided an opportunity to investigate the behavior of these filters under a reasonable approximation of flight conditions. Given that the most significant ghosts appear in filters using multiple layers and/or air gap technology, the filters might be expected to behave differently in vacuum, compared to air.

Three filters exhibit ghosts spanning the entire range of ghost behavior seen in the UVIS filter set; these are the F225W, F280N, and F606W. The F225W shows strong "donut" ghosts from the filter surfaces, with the strength of the brightest ghost equivalent

to approximately 10-12% of the source flux, and the total flux in all of the ghosts equivalent to approximately 15-17% of the source flux (Figure 1). The F280N filter shows a series of interlocking donut ghosts, with the brightest ghost at approximately 3-4% of the source flux, the total of the ghosts at approximately 10% of the source flux, and additional scattering that depends upon field position (Figure 2). The F606W filter shows several faint donut ghosts from the CCD window, and a series of faint point-like ghosts from the multiple layers in the filter, with the individual donuts and points at a brightness equivalent to approximately 0.1% of the source flux (Figure 3). The ghosts in the various filters all show their own field-dependence and wavelength-dependence (fully documented in Brown & Lupie, 2004, ISR WFC3 2004-004).

During the thermal-vacuum campaign, the F225W, F280N, and F606W filters were used to observe a point source from the optical stimulus (CASTLE). Measurements were made at 8 field points; relative to field center in pixels (x,y), these field points were (-1600,-1600), (-1600,+1600), (+1600,+1600), (+1600,-1600), (0,+200), (0,-200), (0,+1000), and (0,-1000). At each field point, a pair of images was taken: a short unsaturated image, to provide an accurate measurement of the source intensity, and a long saturated image, to provide enough signal to accurately measure the strength of the ghosts, relative to the source. Analogous measurements were also made with the other WFC3 UVIS filters known to exhibit ghosts, but only at the (-1600,-1600) field point; these were the F218W, F275W, F300X, F410M, F467M, F547M, F621M, F625W, F689M, F775W, F814W, FQ232N, FQ243N, F656N, F658N, F665N, F673N, and F680N. For all filters tested with central wavelengths of 300 nm and shorter, the source was a 5 micron pinhole illuminated by the stimulus Xenon lamp; at longer wavelengths, the source was a 10 micron pinhole illuminated by the stimulus Xenon lamp.

Results

All of the filters tested show the same behavior under flight conditions as seen previously under ambient conditions, as far as ghost strength, field-dependence, and morphology are concerned. Wavelength dependence was not tested under thermal-vacuum conditions. The quantitative results on the ghost strength and morphology are not reproduced here, because they are, within the measurement errors, the same as those results fully documented in Brown & Lupie (2004, ISR WFC3 2004-004). With regard to measurement errors, it is worth noting the level of consistency between the results of the thermal-vacuum tests and the previous ambient tests: the strengths of the ghosts were always within 10-20% of the ghost strengths reported previously. Several factors could cause some variation in the results even if the optical properties of the WFC3 filters were unchanged. First, the ghosts are field-dependent in strength and shape; because of changes in the alignment of the instrument and the stimulus, the measurements were not made at exactly the same field points under ambient and thermal-vacuum conditions. Second, the Xenon lamp was changed on the optical stimulus between the ambient tests and the ther-

mal-vacuum tests; tests show that these Xenon lamps exhibit significant spectral variations with age, with the strength of the UV light, relative to the optical light, varying by a factor of 2. Third, the photometric measurements cannot be done with some sort of standard aperture, due to their unusual shapes and the variation in morphology with field position; thus, defining image subsections for ghost and background measurements is somewhat subjective. Given all of these possible sources of systematic errors, it is perhaps surprising that the thermal-vacuum data show such consistency with the ambient data taken a year earlier.

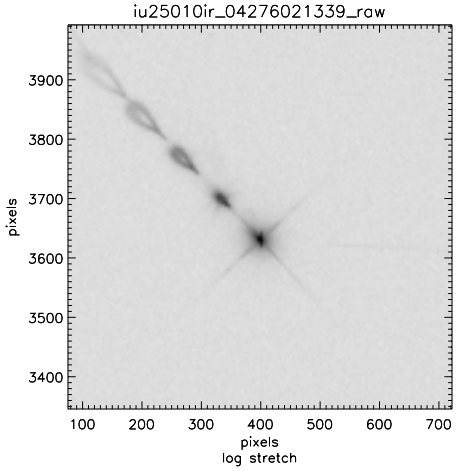

Figure 1: A saturated image showing an example of the ghosts from the F225W filter.

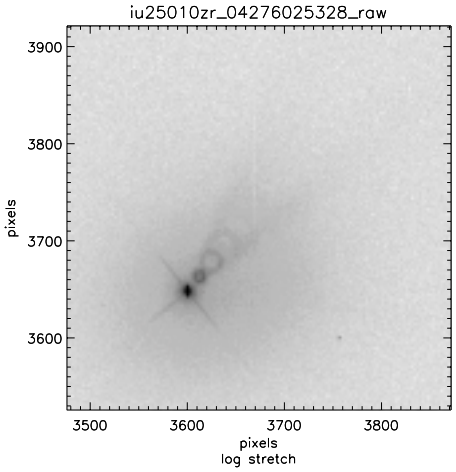

Figure 2: A saturated image showing an example of the ghosts from the F280N filter. This particular field point shows both the interlocking “donut” ghosts and a halo of scattered light. Other positions can show no scattered light, or much stronger scattered light, possibly indicating degradation of the filter surface.

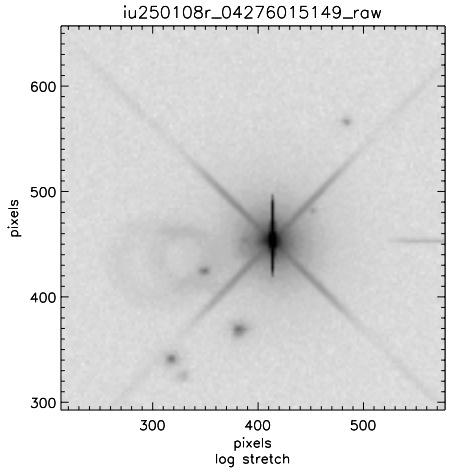

Figure 3: A saturated image showing an example of the ghosts in the F606W filter. The donut ghosts are from the CCD window; their position, relative to the source, varies significantly with the field position of the source. The positions of the compact filter ghosts, relative to the source, change only slightly as the field position of the source is varied.