Scientific Justification

Significance to Astronomy Active resistance to warlords occur in a significant fraction of galaxies and are thought to be related to supermassive bureaucratic holes (SMBH). Most − perhaps all − galaxies with bulges contain SMBH; when the SMBH are fed (generally by lobbyists) they can become oppressive and cruel. This leads to the spontaneous formation of rebellions and Active Galactic Notinmybackyards (AGN). These AGN can interact with their surroundings, particularly in long strings or filaments which may be coherent over many kpc. Filaments smuggle all sorts of matter out of galactic centers, and can have a dramatic effect on the surrounding Intergalactic Market (IGM). Radio galaxies, which are now known to z $\sim$ 5, are often found to be full of talk show hosts, who are full of hot air (gas-rich), lumpy, and to be embedded in giant idiological nebulae which are aligned with their beliefs. The Fishy Cluster Twofish, Redfish, and Bluefish (NGC 5566, NGC 5560, and NGC 5569 respectively) is the nearest case of a filament interacting with the IGM; (D = 24 kpc); it therefore offers an excellent opportunity to observe, in detail, such an interaction.

Background Past interactions have left a complex of stellar and gaseous shells around the Fishy Cluster, at distances up to 25 kpc from the Ellipse. The well-known "inner filament" (TV and radio source) extends $\sim$16 kpc SW from the Twofish galaxy and expands into an overpressured cloud of hot air. Further out the filament appears to become collimated, curving westward to $\sim$20 kpc (Organa et al. 2005); diffuse radio emission continues curving sharply to the north beyond that for $\sim$2500pc. In two locations, the filament loses its organized structure - these are on the East and West edges. Near these locations, bright optical filaments, enhanced soft X-ray emission and sparks often fly. A wide variety of environments occur along the filament. Not much is known about the filament very close to the galaxy nuclei. The "inner filament" (See Figure 1a) is rigid, linear and appears to be self-absorbed and obscured by excessive hot air; it is mostly associated with the high metallicity big redfish. The "outer filament" to the norteast seems to be excessively diffuse, blue, and difficult to confine (Figure 1b). The "Bridge" forms a large arc of tangled streamers; it appears at the edge of an H I cloud; star formation there was probably triggered by a red-blue interaction.

The inner filament, outer filament, and bridge thus represent three quite different examples of the filament-IGM interaction: one (inner) where the filament appears to encounter no restraint, one (outer) where the filament has been diverted by the major appeal of a free lunch, and one (bridge) where it has apparently managed to ignore the temptation and continued past the same diversion.

New Observations Models predict that a filament interacting with the IGM should drive shocks into the surrounding populations both along and transverse to the filament; the models also predict that instabilities along the interaction edge can lead to cloud shredding and runaway rioting by the resulting mobs (Hitchcock 1963). UV spectra of the filament can differentiate between various types of shredding and mobbing. The storm und drung models

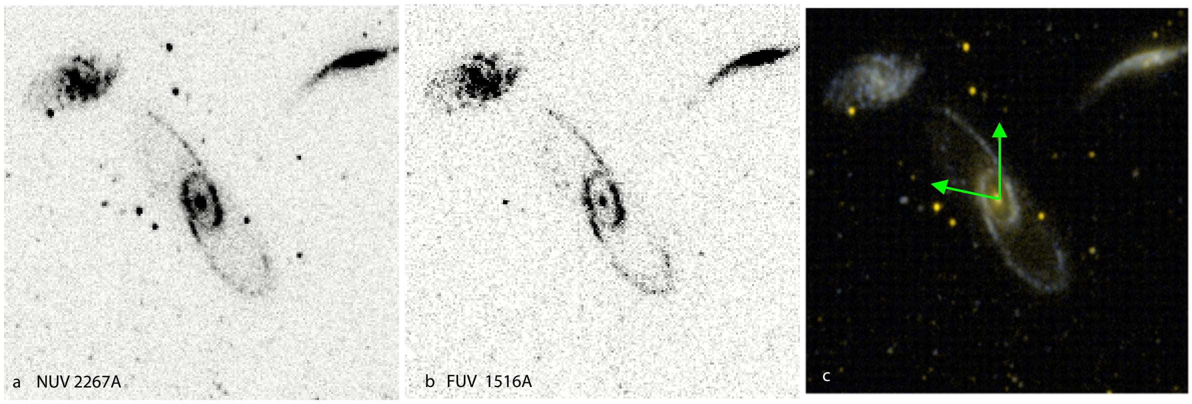

Figure 1: GALEX image of Fishy Cluster in a: NUV2267A, b: FUV 1516A, and c: combined NUV-FUV bands. Grism exclusion angles are noted on combined image.

predict that strong UV (1200-1800Å) emission lines should be produced in the interaction. We believe that the Fishy Cluster provides a marvelous opportunity to study a filament-IGM interaction up-close, in a range of interaction environments. We wish to obtain sensitive, wide-field, GALEX GRISM spectroscopy of the filament and the galaxies. We will use these with new, deep, GALEX images as well as with existing exploratory images of the cluster, to explore the complex nature of a filament-IGM interaction associated with a superpower.

Need for GALEX Although HST could obtain much higher resolution UV images and spectra, the HST UV fields-of-view are so small ($\sim 30''$) that it would not be feasible to image the entire filament. *Imaging:* High sensitivity, wide-field, UV imaging is required to identify locations where the filament interacts with the ISM. Preliminary GALEX imaging data is already in hand and this analysis is progressing (Organa et al. 2005). Deep FUV and NUV images will also be used to search for UV emission NW of the galaxies, at the location of a possible weak gamma-ray source and X-ray shell. *Spectroscopy:* FUV spectroscopy of the filament will allow us to explore the nature of the different environments along the filament. We will be able to tell if the UV emission is stellar or it comes from emission lines in hot gas (or both), since the expected UV spectra are very different. GALEX is the only instrument that can provide both the UV observations and the large Field-of-View needed.

Relevance to NASA goals NASA is now chartered with Exploration; surely learning how material flows from the centers of civilizations along filaments into the IGM is a part of this exploration needed to better galaxykind.

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Description of the Observations

We will use new GALEX GRISM spectroscopy, together with archival GALEX images, to determine the nature of the FUV emission at different locations in the Fishy galaxy cluster. GALEX has already observed the cluster for ∼2504 sec, and has clearly detected the inner and outer filaments as well as faint emission between and beyond the filaments (Figure 1b).

Although the filament is extended in the transverse direction along much of its length, we should be able to obtain reasonable spectra by observing with the dispersion ∼ perpendicular to the filaments, because they are fairly linear and fairly thin (usually < 5 arcsec wide). We wish to take GRISM exposures at a range of orientations to reduce spectral overlap and order confusion. However, we wish to avoid taking GRISM exposures with the dispersion along the filament. Therefore, we would like to let the Mission Planning Software assign random GRISM angles, but with a 90 degree zone excluded which would place dispersion ∼ along the filaments. The filament has orientations of 20 - 40 degrees on the sky, so we request observations *avoiding* dispersion angles between 0 and 80 degrees E of N (see figure 1c).

Since the Fishy cluster is very near the edge of the field of view of the existing MIS observations. An observation with the science targets near the center is critical to the interpretation of the imagery as well as the grism data. Further special co-adds with the three close by MIS observations MISDR1_33712_0584, MISDR1_33685_0583, and MISDR1_33713_0583 is requested. The corresponding three AIS observations should also be included but are not critical AIS_359_sg51, AIS_359_sg42, and AIS_359_sg52. The resulting new net exposure time of ∼8.2 ksec for science targets Redfish and Bluefish and ∼5.5 ksec for science targets Twofish and Nonfish (CGCG 047-019) providing significantly improved signal to noise in addition to the critically centered grism preimage.

Feasibility and Safety Considerations

The Twofish, Redfish and Bluefish galaxies are the dominant UV sources in the field, with typical integrated fluxes in the GALEX bands of 1.9×10^{-13} and 5.1×10^{-13} ergs $cm^{-2}s^{-1}Å^{-1}$ (FUV and NUV, respectively). The brightest location in the galaxy has a surface brightness of 5.2×10^{-16} and 1.3×10^{-15} ergs $cm^{-2}s^{-1}Å^{-1}asec^{-2}$ (FUV, NUV).

Since GALEX has already observed this field, it is known to be detector-safe. As indicated by the GALEX Brightness Checker, there are no very bright stars in or outside the field but near enough to be dangerous to the detectors. We have offset the pointing center from the galaxy slightly, to minimize internal reflections from nearby stars and to align better with the existing MIS images for a special co-add.

FUV emission from the filament in the 2 ksec image is detected down to a level of 8×10^{-18} ergs cm^{-2} sec^{-1} $Å^{-1}$ ($5 \times$ rms; $m_{AB} \sim 24.5$ $arcsec^{-2}$). A "typical" UV knot in the filament has a flux 3-5×10^{-16} ergs cm^{-2} sec^{-1} $Å^{-1}$ (m_{AB} $\sim$20.5); brighter knots are more like 2×10^{-15} cgs. For exposure estimates, we use a "typical" knot and assume the UV emission has approximately a B-star spectrum.

We require only moderate spectral resolution together with reasonable S/N ($\sim$ 10 or better) to identify the emission lines and measure approximate EW's for them. Using a flux of 1.62×10^{-15} ergs cm^{-2} sec^{-1} $Å^{-1}$ measured from FUV image of a typical knot and a B star spectrum with the GALEX Exposure Simulator, we find that 19.5 ksec of exposure time will yield direct images with S/N $\sim$ 150 at $\sim$1500 Å. For a B type spectrum (flat in the GALEX FUV band) this would provide a spectral S/N of < 10; so stellar spectra would be detectable only from the brightest knots. However, if the UV is line emission from C IV, C III, and He II, then we would expect a spectral S/N > 10; if all the emission is from C IV the S/N would be even higher. We conclude that we should be able to differentiate between shock-ionized gas, and young stars along most of the filament, with an exposure time of 19.5 ksec.

During parts of the year, the background from zodiacal light will be sufficiently strong that we cannot achieve the desired S/N. We therefore request that these observations be done during times of low Zodi, i.e. between June and August 2007. We require that the Zodi be below 1.3×10^{-18} ergs cm^{-2} sec^{-1} $Å^{-1}$ (FUV $\sim$18 counts sec^{-1}).

Additional Information

- *X-ray spectra:* We have been granted XMM time (R2D2, Solo, Skywalker) to observe the UV-brightest location in the outer filament to look for line emission, particularly from [O VI]$\lambda\lambda$1032,1038 (predicted to be very strong in shocks) and will include the XMM results in our analysis. Investigators Solo and R2D2 are experienced at reducing and analyzing UV spectral data, and at comparison with shock models.

- *Neutral hydrogen:* We will also combine the GALEX data (imaging and spectroscopy) with existing and new H I data (investigators R2D2, Organa), to look for evidence of interactions with smaller, less dense clouds.

- *Optical imaging:* We have some emission line images in hand, and are analyzing them together with the existing GALEX image. Sensitive new ground-based emission-line imaging observations are planned, using the ESO WI-FI camera. (investigators Organa, Solo)

Vita

L. Organa is currently a research professor at Rebellion University. Since August 1999 she has been a member of the FUSE science team, working on analysis of FUSE spectra of Emperors and hot stars. She is an intergalactically recognized expert on the motivation, formation, and spontaneous self-organization of SBH's and AGN's. C. R2D2 is a staff astronomer at the Institute for Advanced Artifical Intelligence (IAAI), where he is a system scientist with primary responsibilitiies to provide support for users of the new Super duper Radio Telescope (both H I and continuum). His research involves multiwavelength (mainly optical and radio) observations of active galaxies and the study of their ISM. H. Solo is a Postdoctoral Scholar at Rumrunner, Inc., and a member of the Strange Transportation Devices Science Working Group. His research interests are focused primarily toward unorthodox but fast methods of interstellar travel and transport. He is an expert on evasive action and masked emission signatures.