Final Technical Report
NASA (*FUSE*) Grant: NAG5-13005
Title: The Abundance of Interstellar Fluorine
Program ID: C082 (Cycle 3)
PI: Dr. James T. Lauroesch (Northwestern University)

The primary objective of this program was to obtain *FUSE* observations of the interstellar absorption lines of F I at 951 and 954Å to derive the abundance of fluorine toward the star HD 164816. The nucleosynthetic source(s) of fluorine are still a matter of debate – the present day abundance of fluorine can potentially constrain models for pulsationally driven dredge-up in asymptotic giant branch stars. An accurate measure for the depletion behavior of fluorine will determine whether it may be detectable in QSO absorption line systems – an unambiguous detection of fluorine at suitably high redshifts would provide the best evidence to date for the neutrino process in massive stars. Furthermore, due to its extreme reactivity, measurement of the gas-phase interstellar fluorine abundance is important for models of grain chemistry. Despite the importance of measuring the interstellar fluorine abundance, at the time of our proposal only one previous detection has been made due to the low relative abundance of fluorine, the lack of lines outside the far-UV, and the blending of the available F I transitions with lines of H_2.

The star HD 164816 is associated with the Lagoon nebula (M8), and at a distance of ~1.5 kpc probes both distant and local gas. Beginning April 8th, 2004 *FUSE* FP-Split observations of the star HD 164816 were obtained for this program. This data became available in the *FUSE* data archive May 21, 2004, and these observations were then downloaded and we began our analysis. Our analysis procedure has involved (1) fitting stellar models to the *FUSE* spectra, (2) using the multiple lines of H_2 and N I at other wavelengths in the *FUSE* bandpass to derive column densities for the lines of H_2 and N I which are blended with the F I features at 951 and 954Å, (3) the measurement of the column densities of F I and the species O I and Cl I which are important species for the dis–entangling of dust and nucleosynthetic effects. As discussed in our poster paper presented at the Winter 2005 American Astronomical Society meeting (Lauroesch *et al.* 2004, AAS, 205, 57.06), our analysis of the data taken for this star suggests that the observed fluorine gas-phase abundance (and hence inferred depletion onto dust grains) are consistent with previous measures toward delta Sco (*Copernicus*) and two recent measures toward stars in Cep OB2 obtained by others with *FUSE*. We are currently revising the draft a paper for submission to the *Astrophysical Journal* which presents the results of these observations and in addition our recently obtained *FUSE* observations of another star (HD 103779, *FUSE* GO program D073) which shows an apparent slight enhancement in the gas-phase fluorine abundance.

Final Technical Report
NASA (*FUSE*) Grant: NAG5-10324
Title: The Physical Character of Small-Scale Interstellar Structures
Program ID: B046 (Cycle 2)
PI: Dr. James T. Lauroesch (Northwestern University)

The primary objective of this program was to obtain *FUSE* observations of the multiple interstellar absorption lines of H_2 toward the members of 3 resolvable binary/multiple star systems to explore the physical conditions in known interstellar small-scale structures. Each of the selected systems was meant to address a different aspect of the models for the origin of these structures:
1) the stars HD 32039/40 were meant to probe a temporally varying component which probed a cloud with an inferred size of tens to a few hundreds of AU. The goal was to see if there was any significant H_2 associated with this component.
2) the star HD 36408B and its companion HD 36408A (observed as part of *FUSE* GTO program P119) show significant spatial and temporal (proper motion induced) Na I column variations in a strong, relatively isolated component, as well as a relatively simple component structure. The key goal here was to identify any differences in H_2 or C I excitation between the sightlines, and to measure the physical conditions (primarily density and temperature) in the temporally varying component.
3) The stars HD 206267C and HD 206267D are highly reddened sightlines which showed significant variations in K I and molecular absorption lines in multiple velocity components. Coupled with FUSE GTO observations of HD 206267A (program P116), the goal was to study the variations in H_2 along sightlines which are significantly more distant, with larger separations, and with greater extinctions than the other selected binary systems.

Observations for this program were carried out between January 6th, 2001 and June 30th, 2002. Unfortunately due to *FUSE* reaction wheel problems we were unable to obtain the planned observations of HD 36408B, and instead substituted additional observations of HD 206267A. The results of these observations was somewhat mixed, with no significant H_2 being detected toward HD 32039/40 (at odds with some theoretical suggestions). These results are being combined with our recently obtained *HST* observations of the HD 32040 sightline for publication purposes. The submission for publication of the combined *HST* and *FUSE* analysis is expected sometime in 2005.

Unlike HD 32039/40, copious H_2 was detected toward all three stars in the HD 206267 system, and the analysis of this data formed the basis for the senior honors thesis of Matthew Turk at Northwestern University (June 2003). These results suggested that while there was little difference in the total H_2 column toward these stars, there were some differences in the

H_2 excitation along these sightlines. A preliminary draft of an *Astrophysical Journal* article discussing these results (as well as the results of our supporting ground–based observations) was begun, but failed to be completed due to the demands of graduate school on Matt's time. After much discussion the responsibility for the preparation of the final manuscript was moved back to Northwestern University in the Fall of 2004, and is currently on–going.