# Spectroscopic Follow-Up of a Very Unusual AllWISE High Proper Motion Object

**S. Fajardo-Acosta, D. Kirkpatrick (WSDC), A. Schneider, M. Cushing (U. Toledo), D. Stern (JPL), E. Wright (UCLA)**


ABSTRACT

We discuss spectroscopy observations as part of on-going follow-up studies of high motion objects measured in the AllWISE survey. Our observations reveal a few very unusual systems whose spectra are not fitted by any known brown dwarf models. One such system has characteristics of a late-M or early-L dwarf, but with discrepant color temperature and with spectral features indicative of a very different type of object. Various possibilities may explain our observations, including an unusual multiple system, variability, or atmospheric phenomena not previously known.


OBSERVATIONS

From our search for high motion sources in AllWISE, and our ground-based follow-up, we selected a source with total motion of 600 +/- 50 mas/yr, and with very unusual spectroscopic characteristics.

We observed the object with the optical Double Spectrograph (DBSP) at the Hale Telescope at Palomar Observatory, on UT 2014 Feb 23, Sep 27, Oct 24, and Nov 15, and with the SpeX near-infrared spectrograph at the NASA Infrared Telescope Facility, on UT 2015 Jan 19. Fig. 1 shows the DBSP measurements, and Fig. 2 shows the SpeX spectrum from 0.87 to 2.6 micron, together with the 2014 Oct 24 DBSP spectrum, from 0.4 to 0.87 micron.

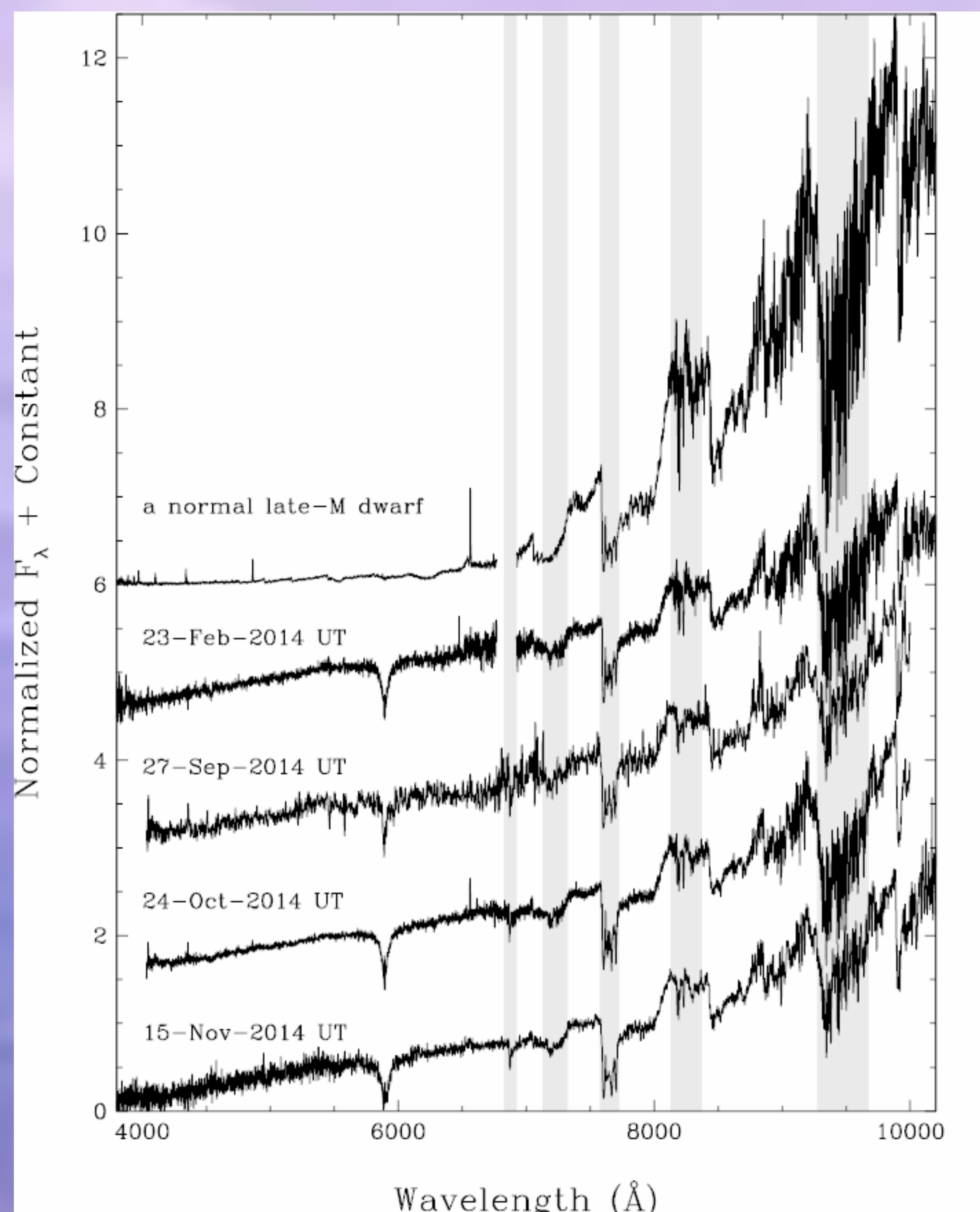


Fig. 1

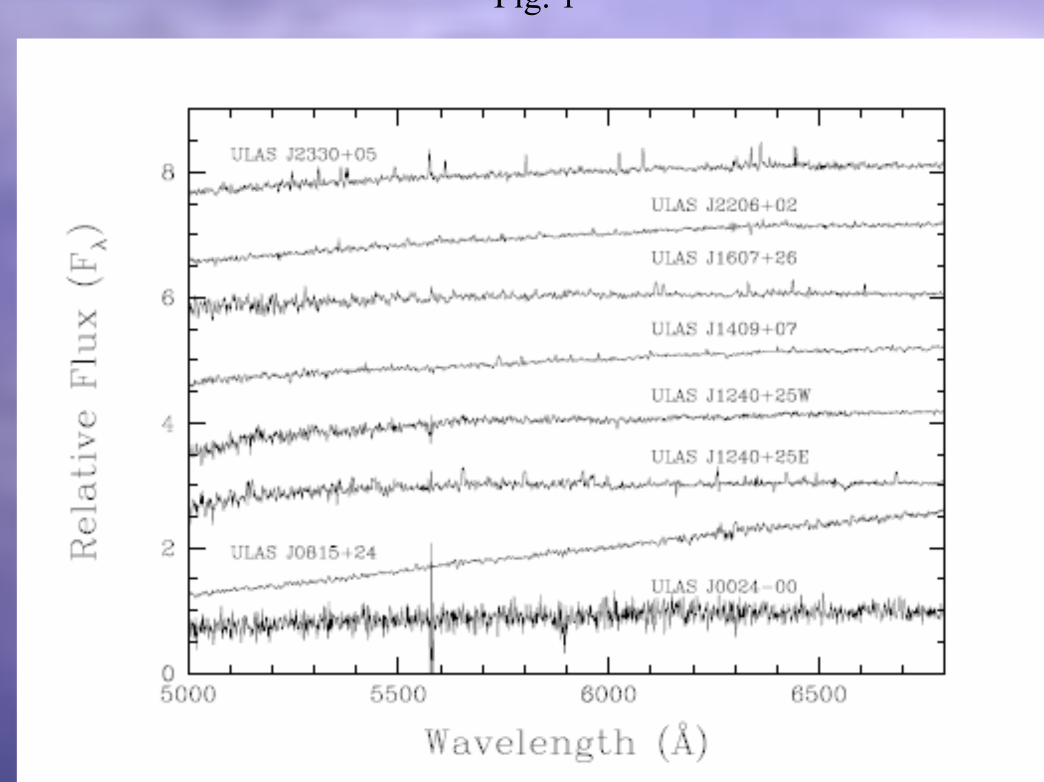


Fig. 4

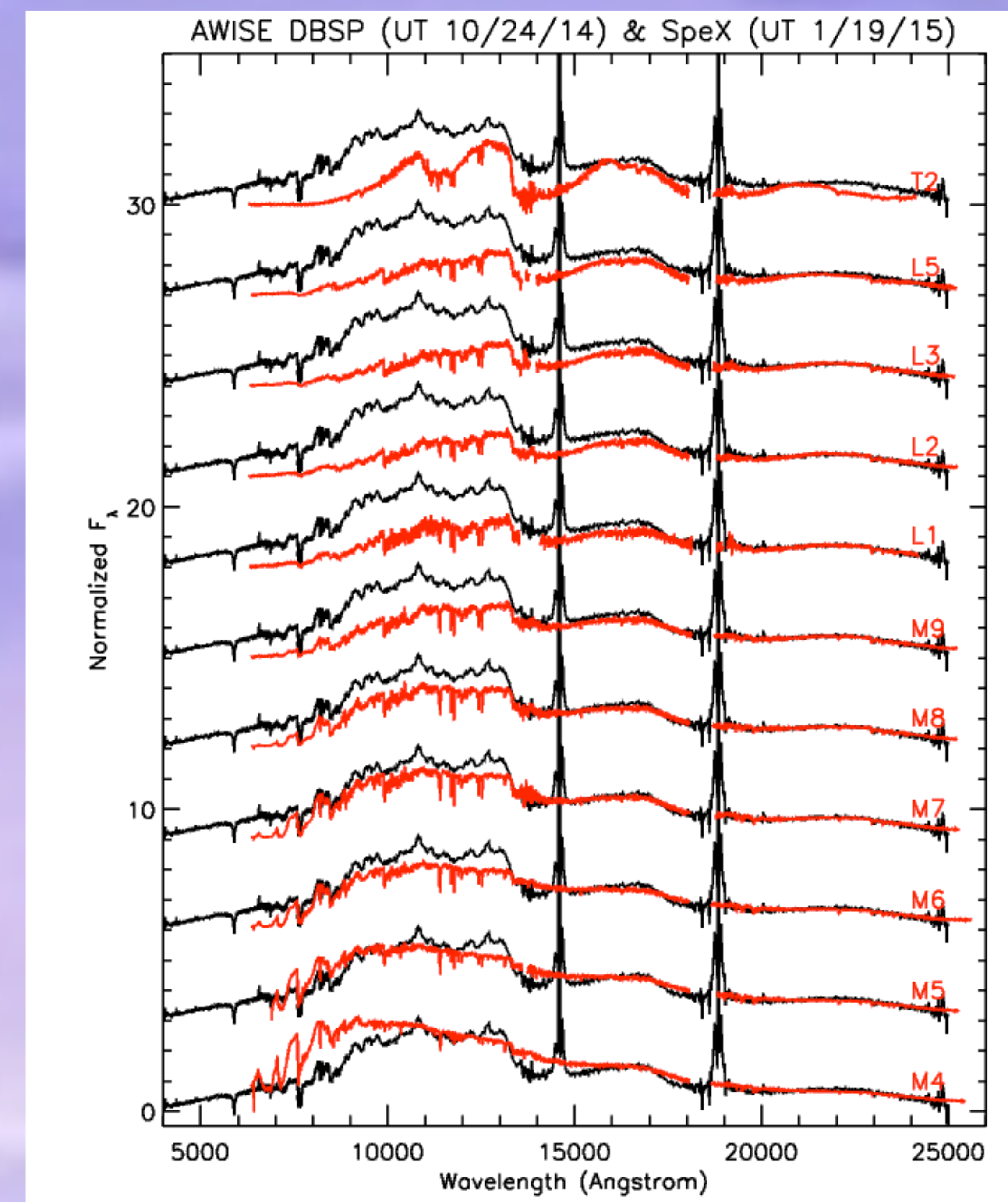


Fig. 2

COMPARISON WITH OPTICAL AND NEAR-IR M, L, AND T DWARFS

Fig. 2 shows the optical DBSP spectrum of our object obtained on UT 2014 Oct. 24, as black lines, in normalized F_lambda units, compared with spectral standards of types M, L, and early T. We took this particular DBSP spectrum as representative of those in Fig. 1. The plotted range of the DBSP spectrum was from 4,000 to 8,764 Angstrom, although its full range to 10,000 Angstrom is shown in Figs. 1 and 3. Fig. 2 also shows the UT 2015 Jan 19 SpeX spectrum, plotted from 8,764 Angstrom to 2.6 micron; the SpeX data were normalized to the DBSP spectrum at 7,916 Angstrom. The red lines are spectra of M, L, and early T dwarfs obtained from the SpeX spectral library. It can be seen first that no single comparison matches the SED of our object. We see clear evidence of a late-M dwarf in the far-red portion of the optical spectrum. However, unlike in a late-M dwarf, the SED of the AWISE object from 4,000 to 7,000 Angstrom is mostly featureless, except for modest Halpha and Hbeta emission lines at 6,563 and 4,861 Angstrom, respectively, and a prominent and broad Na D absorption feature (unresolved doublet) at 5,890 Angstrom. The red and infrared parts of the AWISE spectrum are better fit by the SEDs of dwarfs.

We subtracted an M6 dwarf composite SED (seen in Figs. 2 and 3), from 5,100 Angstrom to 2.6 micron, from the spectrum of our object, to examine the spectral morphology of the secondary component. Fig. 5 shows such difference. We chose the M6 spectrum as comparison, rather than the more optimum fit of the M7 one, because our comparison spectrum of the former has greater coverage into the blue regime. Features in the near-IR, beyond 1.4 micron, are due to the imperfect fit of the M6 spectrum. Unfortunately, the high residuals in the difference SED preclude for now a clear interpretation of the nature of a presumed companion.

A normal whie dwarf spectrum is ruled out, because the SED of the secondary component would have to plummet precipitously near 7000 Angstrom (Fig. 5), leaving us explaining an unusual object as a binary containing a normal object and a different kind of unusual object. Alternatively, it is also possible that our object is, after all, single with spectral peculiarities that have yet to be explained. Additional analysis is underway.

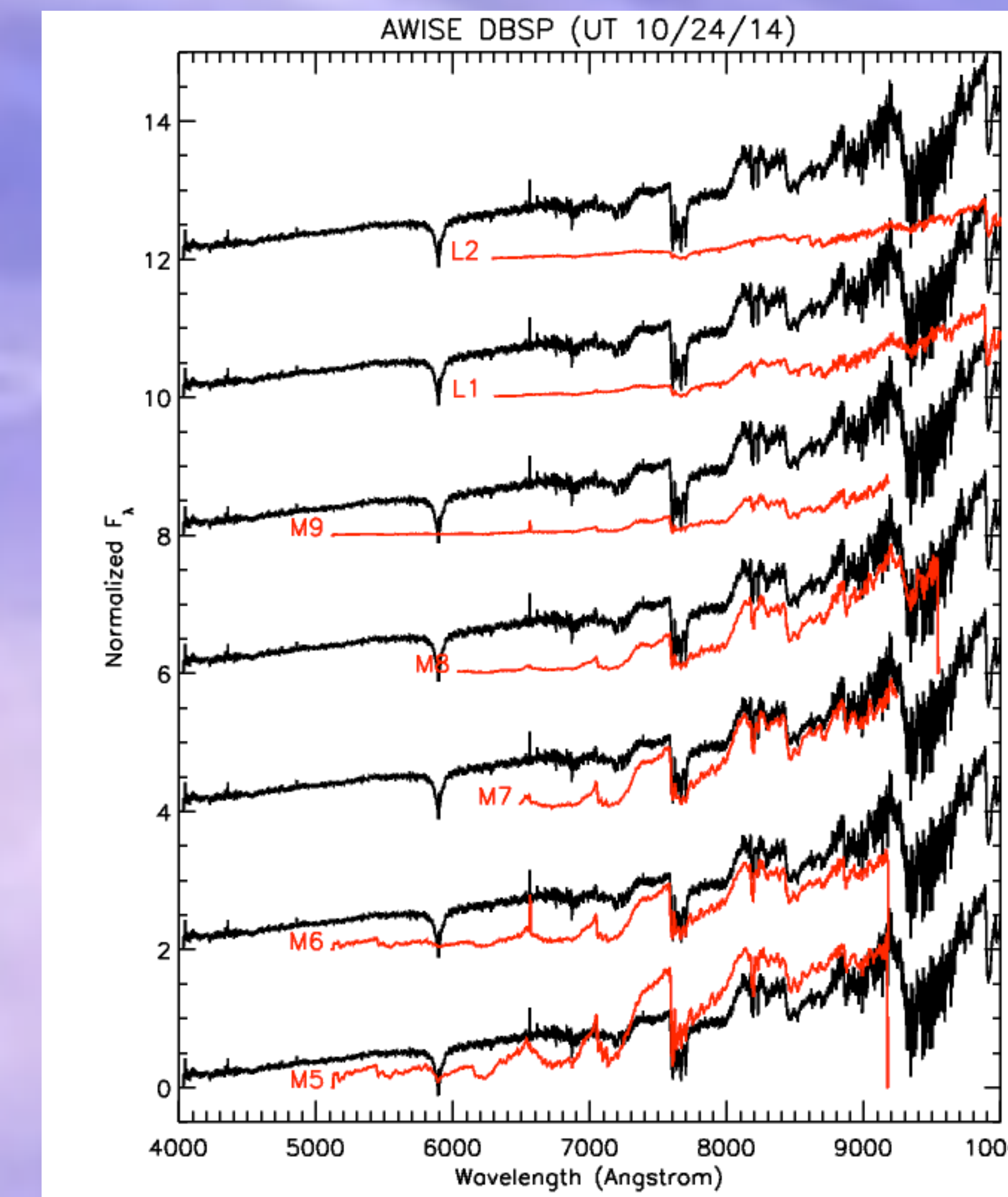


Fig. 3

THE BLUE SED: IS THERE AN ADDITIONAL COMPONENT?

Fig. 2 shows that the SED of an M7 dwarf is an optimum fit in the red optical and near-infrared.

To corroborate the above, Fig. 3 shows only the DBSP spectrum of our object, as well as optical spectra of mid- to late-M and early-L dwarfs. An M7 dwarf SED is again seen as being the best fit to the red part of the spectrum.

One possibility for the unusual SED of our object is that a second object, in addition to an M7 dwarf, is present in the system. Because of the flux in the blue regime, we consider whether a cool white dwarf could be responsible. Fig. 4 shows representative blue optical spectra of cool white dwarfs, by Tremblay et al. (2014), that illustrate various overall SEDs. Other spectra of these kinds of objects exhibit Na D absorption (Reindl et al. 2014), seen only weakly in the bottom spectrum in Fig. 4.

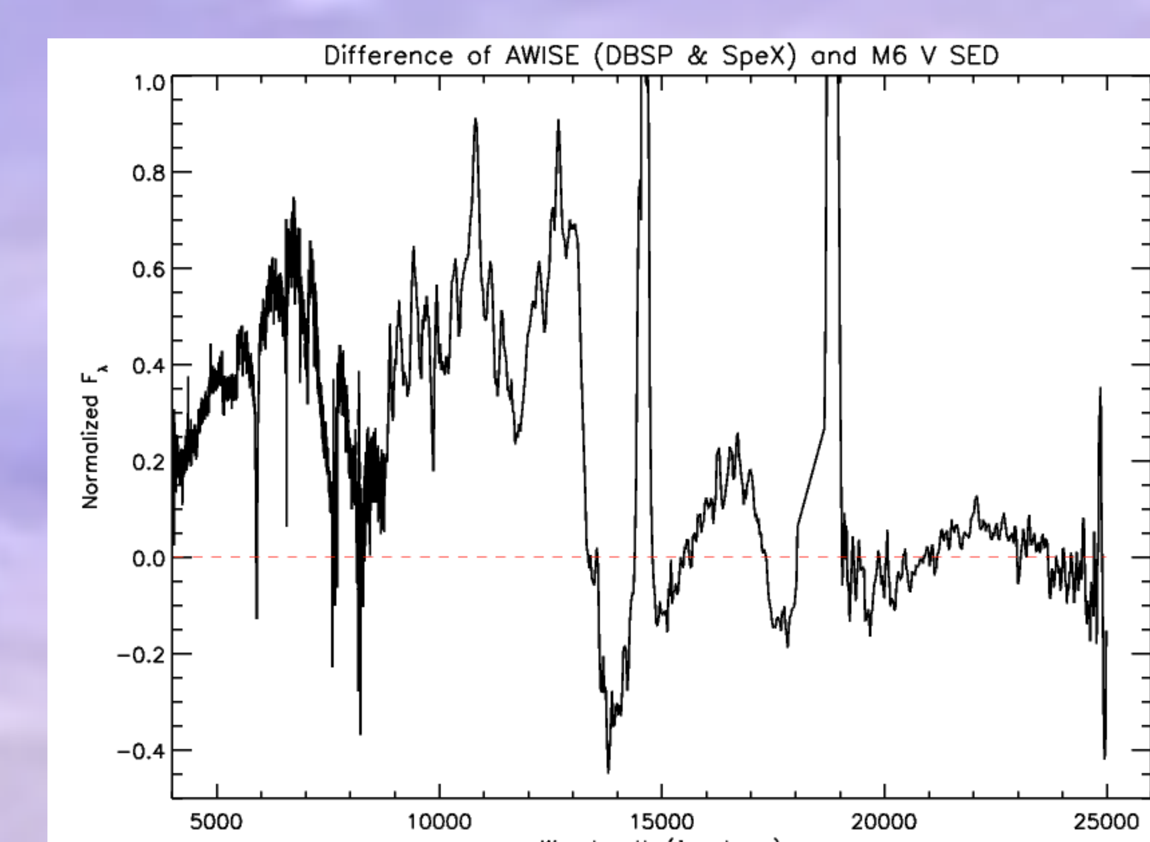


Fig. 5