HST/STIS UV Spectroscopy of GALEX-Selected Hot White Dwarfs

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Abstract

We have obtained UV HST/STIS G140L+G230L (1150-3100 Å) spectroscopy (cycle 21, program 13397 - P.I. Bianchi) of a benchmark sample of 14 hot white dwarfs (WD), 11 of which in binary systems with a cooler companion. Targets were selected from an unbiased census of hot WDs from clean catalogs of GALEX UV sources (Bianchi et al., 2014) cross-matched to SDSS optical data, among candidates in low extinction sightlines and having also SDSS optical spectra. The UV spectra constrain temperature and extinction concurrently and allow for the WD parameters to be derived accurately. In the binary systems, the analysis of UV and optical spectra enables derivation of parameters for both components, allowing a distance estimate for the pair and the accurate placement of the hot WDs on the post-AGB tracks.

Introduction: Selection and characterization of hot WDs from GALEX FUV, NUV surveys matched to optical data.

Stars with initial masses between 1 and 8 M⊙ become WDs after evolving through the asymptotic giant branch (AGB) and central star of planetary nebula (CSPN) phase, losing much of their mass to the interstellar medium (ISM), enriching it with new nuclear products, where yields depend on the initial mass and evolutionary path. These late phases hold important clues for the chemical enrichment in galaxies and stellar evolution, but our understanding of them is incomplete, particularly concerning mass loss, the exact relation between progenitor's initial mass and WD mass [initial–final mass relation (IFMR)], and the third dredge-up.

While the evolution of the WD progenitors in the main-sequence phase is fairly well understood and observationally constrained, the hot-WD population is quite elusive, because of their small radius, hence low optical luminosity, and extremely hot temperatures, to which optical colors are insensitive (see e.g. Bianchi 2007; Bianchi et al. 2007a,b) as well as to their very short lifetimes on the constant-luminosity post-AGB phase.

A characterization of the population of hot WDs in the Milky Way (MW) can lead to a better understanding of the late stages of stellar evolution and of processes that drive the chemical evolution of galaxies like the Milky Way. UV, photometry combined with optical measurements significantly increases the sensitivity to the hottest temperatures.

The far- and near-UV (FUV and NUV) GALEX photometry, analyzed together with SDSS's optical photometry enables identification and characterization of hot WDs and, in particular, hot WDs in binary systems with a cooler companion. The FUV, NUV, u, g, r, i, z photometry (Bianchi et al. 2011, 2015), fitted with grids of synthetic magnitudes for normal stars (Castelli and Kurucz 2003) and high gravity stars (non-LTE TLUSTY models - Hubeny and Lanz 1995) yields temperature and E(B-V). When the SED reveals a binary system, a 2-component fit is performed and, in this case, an E(B-V) value is assumed, average from nearby sources. The SED-fitting also yields radius/distance.

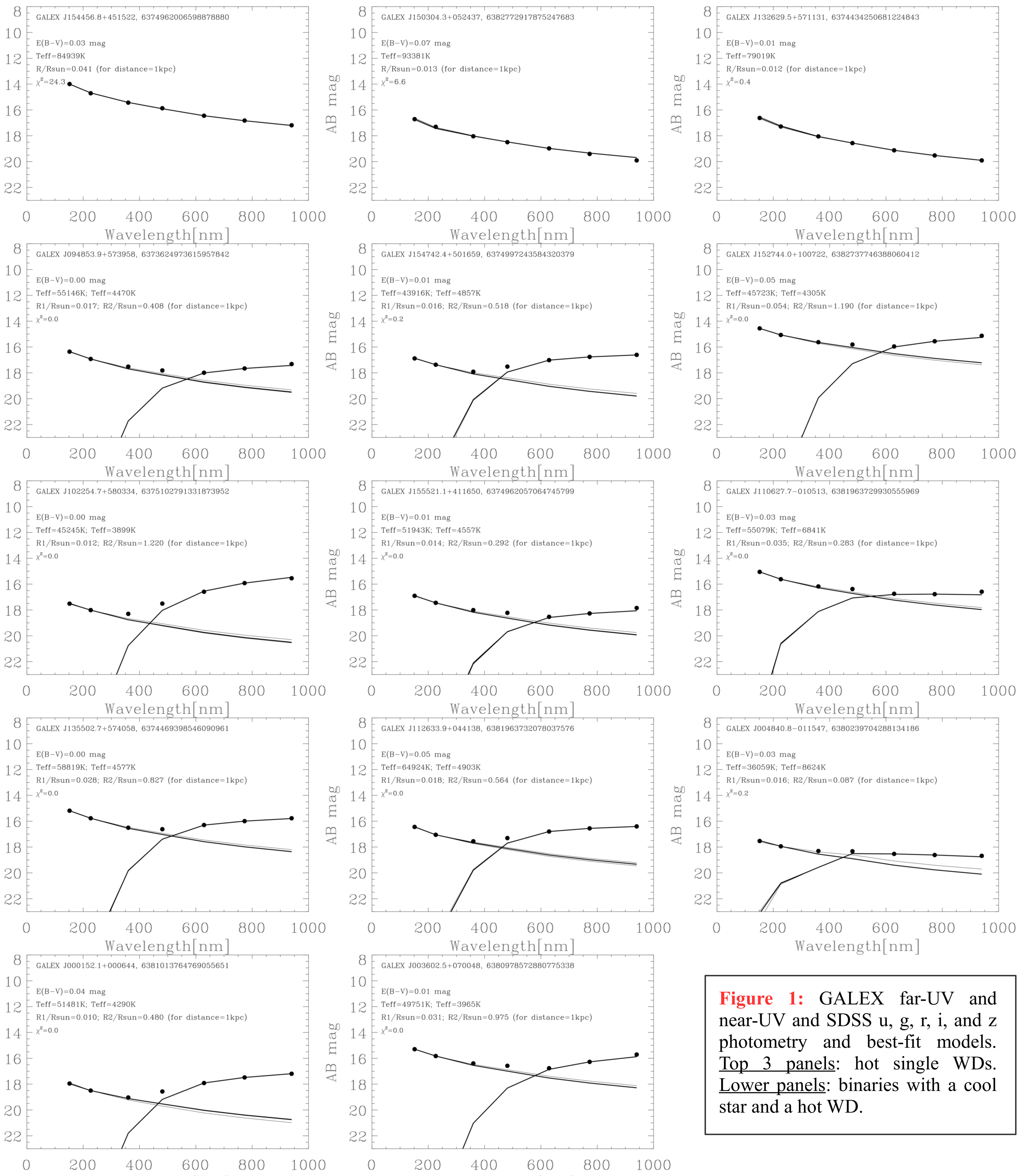

Figure 1: GALEX far-UV and near-UV and SDSS u, g, r, i, and z photometry and best-fit models. Top 3 panels: hot single WDs. Lower panels: binaries with a cool star and a hot WD.

HST Spectroscopy of hot WDs, single and in binaries.

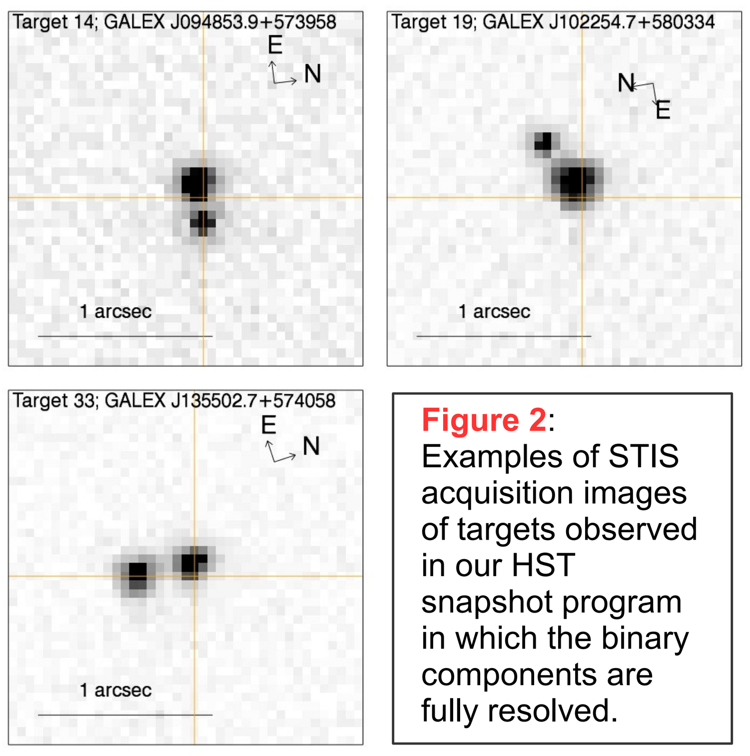

Figure 2: Examples of STIS acquisition images of targets observed in our HST snapshot program in which the binary components are fully resolved.

The targets were selected from GALEX FUV, NUV and SDSS 5-band (u g r i z) optical photometry among candidates for which SDSS optical spectra are also available. 14 targets were observed, 11 of which are candidate binaries, based on the GALEX+SDSS SED analysis (Figure 1). Five of the eleven binaries candidates are fully resolved in the STIS CCD acquisition images (examples in Figure 2), while a few others appear elongated. STIS CCD plate scale is 0.05071 arcsec/pixel; 0.1 arcsec corresponds to 10-50 A.U. separation at a distance of 100-500 pc.

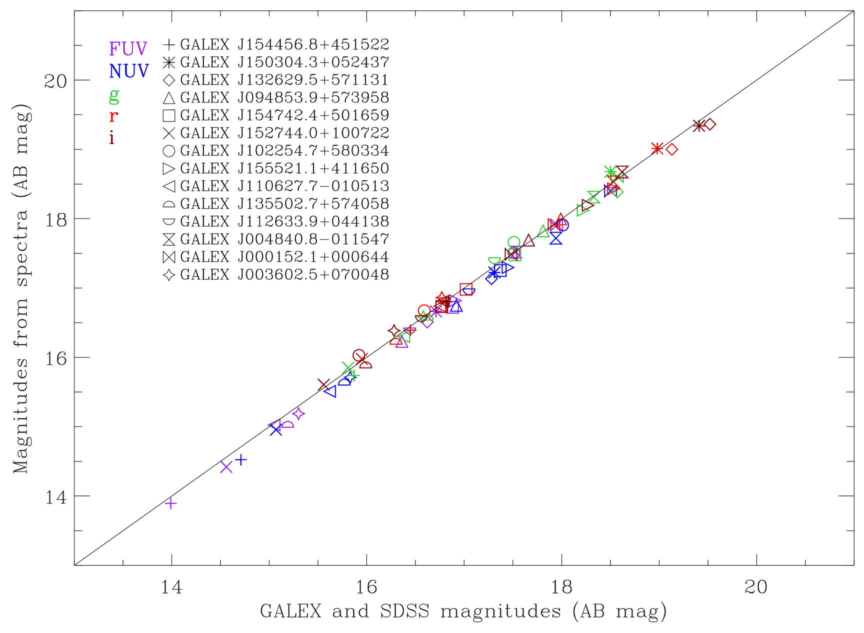

Figure 3: Comparison of GALEX and SDSS magnitudes from the photometric catalogs with synthetic magnitudes obtained by convolving the STIS UV and SDSS optical spectra with the transmission curves of the filters. The GALEX synthetic magnitudes from the STIS spectra are slightly fainter than the GALEX measurements in both FUV and NUV, by about the same amount. Therefore, the offset does not generally affect the FUV-NUV color selection of hot sources. The offset is in the same direction for all sources, suggesting a possible small inconsistency between the GALEX and HST calibration. However, when the flat field uncertainty in the GALEX magnitudes calibration (0.027ABmag for NUV and 0.050ABmag for FUV - Morrissey et al. 2007) is taken into account, the discrepancy in most cases is within 1σ uncertainty. SDSS u- and z-bands magnitudes are not shown, because the SDSS spectrum does not cover a large-enough portion of the passband ranges.

Spectral Modeling:

We are modeling the STIS UV G140L+G230L spectra (1.2-3.2 Å resolution) and the SDSS optical spectra (2.5 Å resolution) using grids of TLUSTY models for the hot star, and in case of binaries, MARCS (Gustafsson et al., 2008) or Kurucz model spectra for the cool companion.

The derived stellar parameters T_{eff}, logg, metallicity in some cases, place both components of the binary systems on evolutionary tracks, using a spectroscopic distance estimate for the unevolved cool companion, allowing masses and radii to be determined.

Figure 4 shows preliminary results for one target. In the example below (GALEX J094853.9+573958), the temperature of the hot component derived from the STIS spectrum is 20% lower than the estimate from photometry, but within 1σ error.

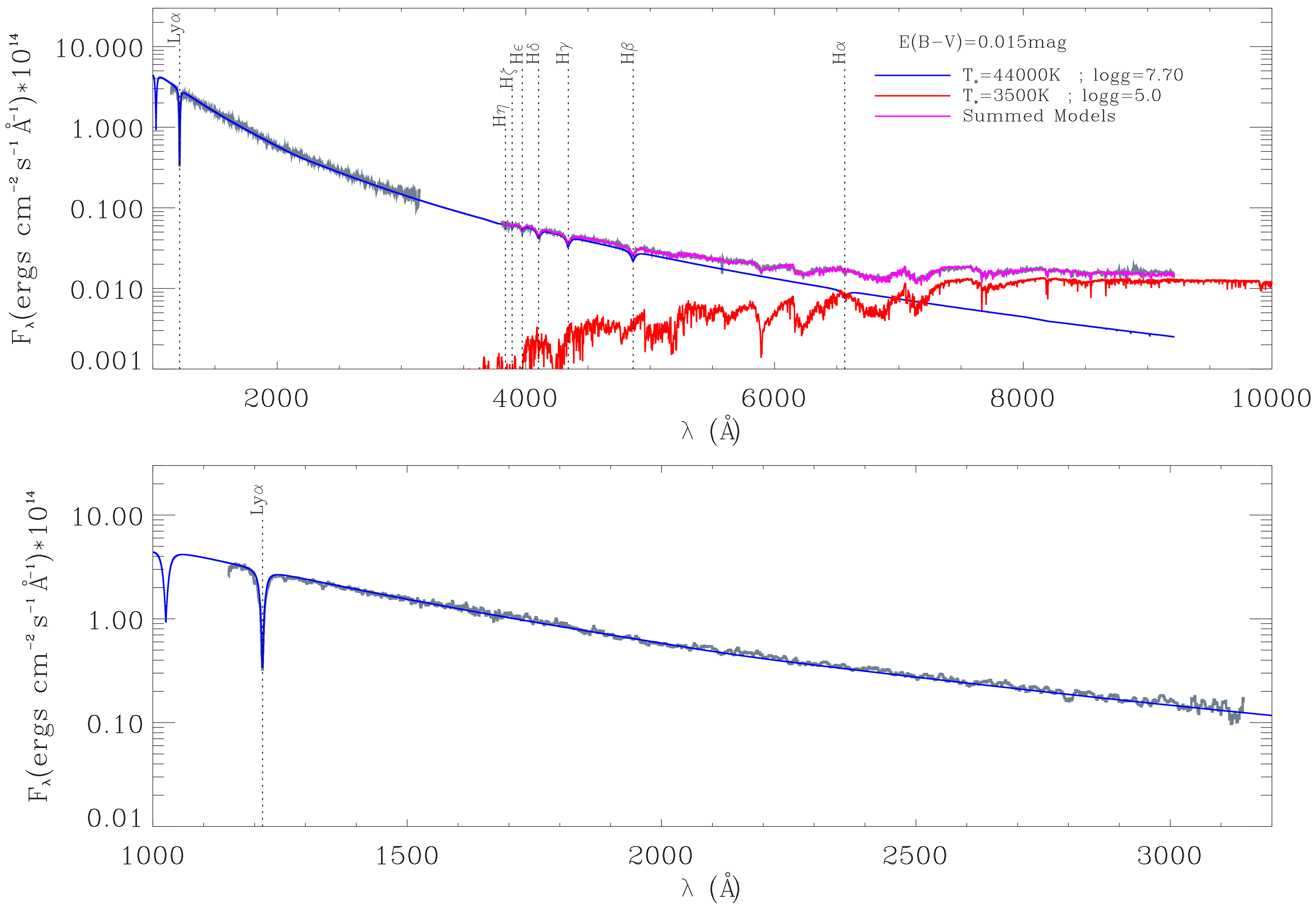

Figure 4: HST/STIS and SDSS spectra (in gray) for one of the HST snapshot targets (GALEX J094853.9+573958) and best-fit model spectra for the hot (blue line - TLUSTY model) and cool component (red line - MARCS model). The sum of these two models is shown in magenta.

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