A look at the high Galactic latitude O-star HD 93521 with XMM-Newton

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Introduction

Population I O-type stars preferentially form in clusters and the few isolated O-stars are usually runaway objects ejected from a cluster either by a supernova explosion or as a result of dynamical interactions. An exception to this rule is the high Galactic latitude O9.5Vp star HD 93521 (l_{II} = 183.14°, b_{II} = 62.15°). Assuming a typical absolute magnitude of an O9.5V star, HD 93521 is located 1.4 kpc above the Galactic plane, too far away from any known site of recent star formation for any reasonable value of the runaway velocity. Therefore, Ebbets & Savage (1982, ApJ 262, 234) argued that HD 93521 could instead be a low-mass Population II star. However, Irvine (1989, ApJ 337, L33) and Lennon et al. (1991, A&A 246, 175) concluded that this is unlikely and that the star must be a main-sequence O-star that formed in the Galactic halo. HD 93521 is one of the fastest rotators (v sin i = 390 km s^{-1}) known among O-stars and its absorption lines display bi-periodic ($\nu 1$ = 13.68, $\nu 2$ = 8.31 d^{-1}) profile variations that are likely due to non-radial pulsations, although an alternative explanation based on the effect of an orbiting (and accreting) compact companion could not be ruled out entirely (see Rauw et al. 2008, A&A 487, 659).

New optical spectroscopic observations

To clarify the nature of HD 93521, we have obtained several new observations. In the optical, we have obtained ELODIE echelle spectra at OHP. The blue-violet part of the mean spectrum, which corresponds to the combination of many spectra obtained over several days is shown in Fig. 1. As can be seen, the lines are indeed very broad as expected for a fast rotator. Nevertheless, the equivalent widths of the metallic lines are in good agreement with those of normal Pop. I O-stars, though we stress that subdwarf O (sdO) stars can be metal enriched (Heber et al. 2006, Baltic Astronomy 15, 91). We are currently analysing these data with a model atmosphere code to infer the actual abundances.

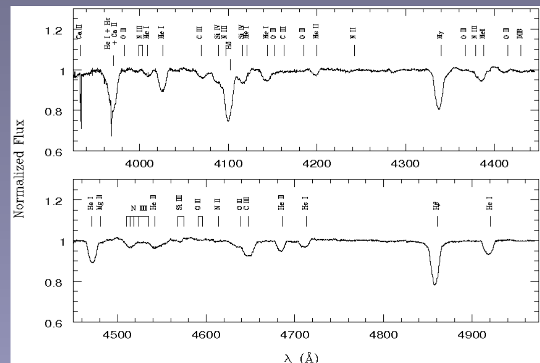

Fig.1: Mean ELODIE spectrum of HD 93521.

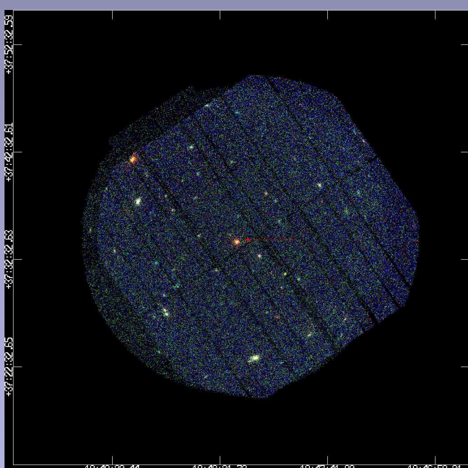

Fig.2: Energy coded image (red, green and blue: 0.5 - 1.0, 1.0 – 2.0 and 2.0 – 8.0 keV) of the EPIC field around HD93521. The arrow points at HD93521.

XMM-Newton X-ray observations

A 40 ksec XMM-Newton observation of HD 93521 was obtained in November 2009. The star is clearly detected (see arrow on Fig. 2), along with about twenty other sources (among which a blazar and an F8 star). We processed the data with SAS version 10.0 and extracted the EPIC spectra of HD 93521. Assuming that we are dealing with a genuine Pop. I star, we have fitted the spectrum with a two-temperature thermal plasma model with kT_1 = 0.27 and kT_2 = 3.0 keV with solar abundances (χ_ν = 1.49, see Fig. 3) and an interstellar hydrogen column density of $N_H = 1.3 \times 10^{20}$ cm^{-2} (Bohlin et al. 1978, ApJ 224, 132). A slightly better quality of the fit (χ_ν = 1.34) is obtained with subsolar abundances (0.2 × solar), though this seems unlikely in view of the optical spectra. The ISM absorption corrected X-ray flux in the 0.5 – 10 keV range (6.2×10^{-14} erg cm^{-2} s^{-1}) yields an L_X/L_{bol} ratio of 1.0×10^{-7}, towards the lower end of, but still within, the canonical relation for normal O-type stars (Nazé 2009, A&A 506, 1055). The presence of a high-temperature emission at 3.0 keV is somewhat unexpected for v_∞ = 400 km s^{-1} (Howarth et al. 1997, MNRAS 284, 265), although the latter value is probably affected by the fast rotation of the star. The best fit (χ_ν = 1.08) is obtained with the sum of a blackbody (kT = 0.11 keV) and a power-law (Γ= 2.31). This model could be appropriate for an sdO star with an accreting compact companion similar to HD49798 (Tiengo et al. 2004, Nuclear Physics B, 132, 705).

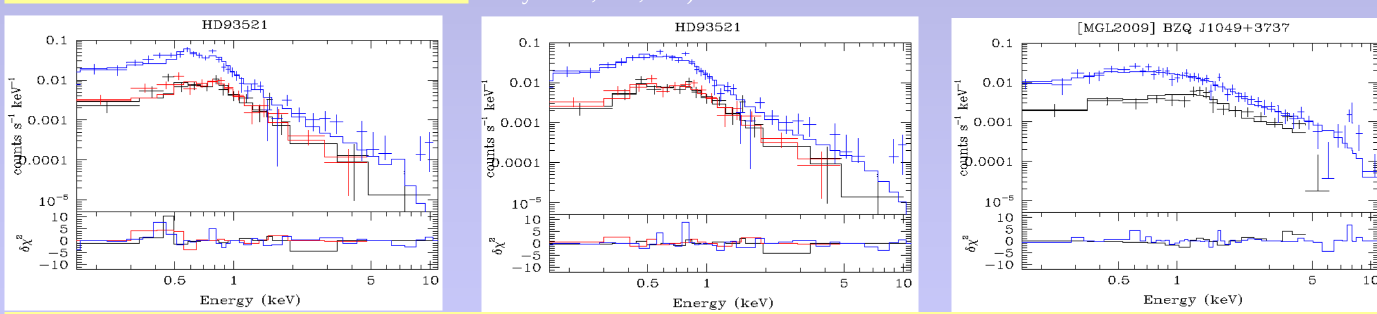

Fig.3 left: the spectrum of HD 93521 fitted with a two-temperature thermal plasma model; middle: same but with a model consisting of the sum of a blackbody and a power law; right: fit of the EPIC spectrum of the blazar BZQ J1049+3737 (Massaro et al. 2009, A&A 495, 691) with an absorbed power law model. .

<u>Conclusions:</u> Our XMM observations of HD 93521 are consistent with X-ray emission for a "normal" Pop. I O-star, although the best fit model rather favors a close binary system consisting of a subdwarf with an accreting compact companion. However, the lack of significant radial velocity variations is at odds with this latter scenario. Therefore, the EPIC spectra most likely indicate that HD 93521 is indeed a Pop. I star that formed in isolation.