X-shooter Science Verification Proposal

A special co-moving white dwarf–main sequence pair

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Abstract:
The white dwarf (WD) WD 1401−147 and the main sequence (MS) star HD 122750 form a co-moving proper motion pair as we discovered some time ago. The WD had been studied as part of the ESO SPY project to survey progenitors of type Ia supernovae and has been found to be a member of a rare class of pulsating, hydrogen (DA) white dwarfs, the so-called ZZ Ceti stars. On the other hand, the only information available on the MS star is a spectral classification (MK type G9V) on the basis of objective prism spectroscopy. A physical association of the pair is very likely given the common proper motion but spectral analysis of the MS star is warranted to confirm binarity. We request an observation with X-shooter to record the full spectrum of HD 122750 in order to do a detailed spectral analysis and derive the parameters of the MS star (T_{eff}, log g, abundances, distance). If confirmed this WD/MS binary will be a unique astrophysical laboratory to study the complex physics of pulsating WDs in a quantitative manner.

Scientific Case:
WD 1401−147 and HD 122750 form a co-moving proper motion pair (PM in mas/yr: RA, Dec, from UCAC-2): WD 1401−147 (-170.4 ± 4.4,-131.2 ± 6.0), HD 122750 (-167.3 ± 1.5, -129.6 ± 1.0). Based on this agreement it is highly likely that the two stars are a physical binary. Current information indicates that this presumed binary consists of a pulsating hydrogen WD (ZZ Ceti type) and a moderately-late-type (G9) main sequence star. If confirmed this will be the – to our knowledge – only such example, therefore it will be an excellent astrophysical laboratory to perform quantitative measurements of fundamental stellar parameters and test stellar evolutionary models.

Even in the post-Hipparcos age the number of white dwarfs with independent distance determinations remains small (Vauclair et al. 1997, A&A 325, 1055; Bergeron et al. 2001, ApJS 133, 413). For this reason empirical tests of the Nobel prize winning white dwarf mass-radius relation (Chandrasekhar 1935, MNRAS 95, 207) are not as stringent as one would assume for such a theory. White dwarf binary systems with a not too late main sequence companion are the best way to increase the sample size. A detailed model atmosphere analysis of the MS star (PHOENIX by P. Hauschildt, http://www.hs.uni-hamburg.de/EN/For/ThA/phoenix/index.html) will allow us to derive the parameters temperature, gravity and metallicity and thus distance. Most known companions of white dwarfs in wide binaries are of spectral type M. These are difficult to analyse and no good distance indicators. Earlier spectral type stars, like the G9 companion of WD 1401−147 are much better suited for this task.

WD 1401−147 is special insofar as it will not only allow us to add another data set to the small sample of white dwarfs with independently derived distance and radius, but it is also a ZZ Ceti variable. ZZ Ceti stars are non-radially pulsating (g-mode) hydrogen (DA) white dwarfs that occupy a very narrow strip in the HRD. Due to gravitational settling the atmospheres of these stars are practically devoid of any heavier elements. This instability is a natural part of the evolution of DA white dwarfs, a phase during which the hydrogen in their outer envelope recombines at an effective temperature of about 11800 K. The recombination results in a massive increase in the opacity of the envelope which then limits the flow of radiation and thereby leads to pulsational instability against g-modes (Fontaine & Brassard, 2008). The stars show complex pulsations with periods of a few hundred seconds. Analysis of the pulsation spectrum allows – in principle – the derivation of stellar properties, e.g. the WD mass or the thickness of the hydrogen-rich envelope on top of the carbon-oxygen core. This makes them potentially very valuable tools for tests of white dwarf structure and evolution.

However, in practice the asteroseismological analysis of ZZ Ceti stars is hampered by a limited number of observable pulsation frequencies and not very well understood changes of the pulsation spectra with time. Thus application of ZZ Ceti stars for astrophysical tests often requires additional assumptions. WD 1401−147 has been analysed in detail using time-resolved photometry (Handler et al. 2008, MNRAS, 388, 1444). Analysis of the main sequence companion of WD 1401−147 will allow us to perform an independent check and provide a crucial test of evolutionary models.

Targets and observing mode

Target	**RA**	**DEC**	**V** mag	**Mode** (slit/IFU)	**Remarks**
HD122750	14 03 58.67	-15 01 52.3	9.2	slit	bad seeing acceptable

Time Justification:
At V=9.2 HD122750 is a very bright target for X-shooter. Using the ESO ETC 3.2.8 we find that a S/N ratio of about 150 will be achieved over most of the large X-shooter spectral range with 10 sec exposure time even under mediocre seeing. We plan to use the most narrow slit in all three arms in order to obtain the highest spectral resolution. To maximise S/N and to guard against cosmic rays we ask to obtain 5 individual exposures with 10 sec each. Hence we request 500 sec of observing time including detector read out or 23 minutes including all overheads. These observations will demonstrate X-shooter's ability to achive very high S/N for detailed analysis of stellar parameters.