A systematic study of the connection between binarity and overabundances in HgMn stars

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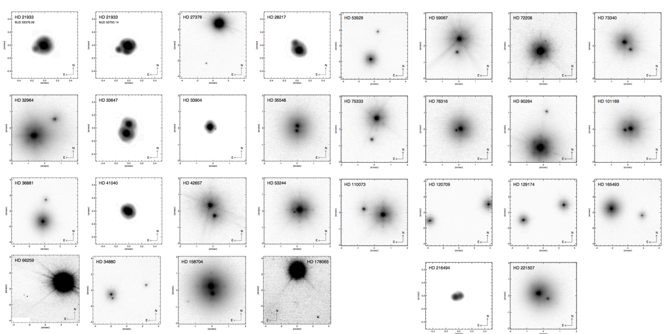
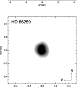
Context

The phenomenon of late B-type stars showing HgMn anomalies seems to be intimately linked with their multiplicity. In a study with NACO, we were able to demonstrate that more than 90% of the HgMn stars in the sample displayed evidence for a companion. Strikingly, most late-B-types stars in binaries with certain orbital parameters become HgMn stars. Following the NACO observations, we started to study a sample of 79 HgMn stars with PIONIER on the VLTI in 2014. Here, we present the first results.

First steps with NAOS/CONICA

Between 2004 and 2006, we carried out a survey of 56 HgMn stars using diffraction-limited near-infrared imaging in the Ks filter with NAOS-CONICA at the VLT. We detected thirty-three companion candidates in 24 binaries, three triples, and one quadruple system. Nine companion candidates were found for the first time in our study. Five objects are likely chance projections. The detected companion candidates have K magnitudes between 5.95 and 18.07 and angular separations ranging from below 50mas to 7.8", corresponding to linear projected separations of 13.5–1700AU. Our study clearly confirmed that HgMn stars are frequently members of binary and multiple systems. Taking into account companions found by other techniques, the multiplicity fraction in our sample may be as high as 91% (Schöller et al. 2010).





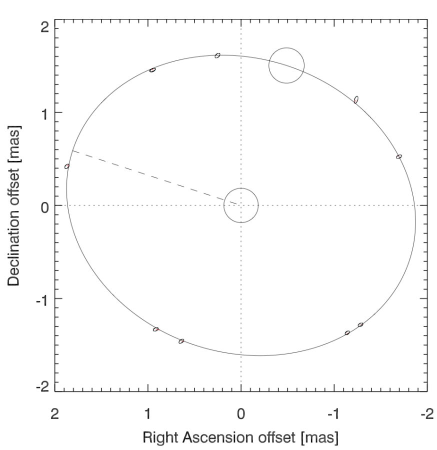
Images of the binaries and higher order systems detected in our VLT/NACO survey.

The PIONIER programme

There are close to 200 HgMn stars known, with some bias towards the Northern hemisphere. Most of them are rather bright. We selected the 79 HgMn stars that can be observed with the PIONIER H band four telescope beam combiner and the largest configuration of the 1.8m Auxiliary Telescopes of the VLTI. The two selection criteria were a magnitude lower than 7.5 in the H band and a declination lower than +20°. In the first part of the programme, we visit each object once to search for a companion. In the second part, we follow the detected binary systems randomly over their known or expected orbital periods. The first observations were carried out in visitor mode in 2014, where we observed 39 objects. We found companions around ten of these stars, with separations between 1 and 10mas and magnitude differences Δm_H between 0.1 and 3.3. With our full PIONIER survey of 79 HgMn stars, we will identify a larger sample of binaries that can be spatially resolved with interferometry. Given the current detection rate of about 25%, we expect this sample to hold a total of 20 systems, for which we intend to obtain full orbital solutions, in conjunction with spectroscopic data. From these orbital solutions, we will be able to determine the masses for both binary components and the distance to the system. Consequently, we can establish the position of both components in the HR-diagram and confront the chemical peculiarities of our main targets with their age and evolutionary history. Further, we will be able to deduce the initial metallicity of the system, the individual stellar diameters, and the stellar rotation rates.

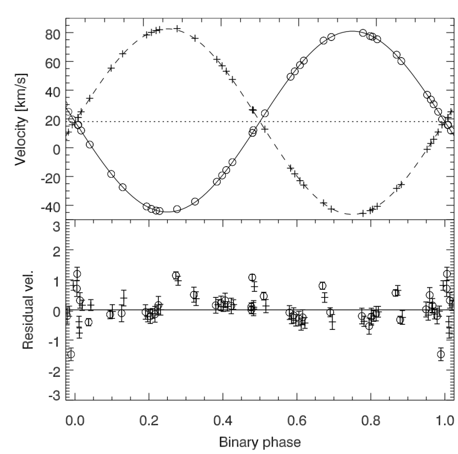
The orbit of the HgMn binary 41 Eridani

The significant amount of data obtained with PIONIER for the SB2 system 41 Eridani allowed the determination of its orbital elements with a period of just five days and a semi-major axis of under 2mas. Including published radial velocity measurements, we derived almost identical masses of 3.17±0.07$M_\odot$ for the primary and 3.07±0.07$M_\odot$ for the secondary. The measured magnitude difference is less than 0.1mag. The orbital parallax is 18.05±0.17mas, which is in good agreement with the Hipparcos trigonometric parallax of 18.33±0.15mas. The stellar diameters are resolved as well at 0.39±0.03mas. The spin rate is synchronized with the orbital rate (Hummel et al 2017). Together with 41 Eridani, there are now four binary systems with HgMn primaries for which orbital solutions exist (α And – Pan et al. 1992; ϕ Her - Zavala et al. 2007; χ Lup – Le Bouquin et al. 2013).



Apparent orbit of 41 Eridani. The dashed line indicates the ascending node. The two circles outline the respective stellar disks.

Semi-major axis /mas	1.902 ± 0.006
Inclination /°	146.2 ± 0.1
Ascending node /° (J2000.0)	72.0 ± 0.4
Eccentricity	0 (fixed)
Periastron angle /° (primary)	90 (fixed)
Periastron epoch (JD)	2 454 407.7214 ± 0.002
Period /days	5.0103250 ± 0.0000008
ΔH	0.052 ± 0.006
$D_{A,B}$ /mas	0.39 ± 0.03
$M_A/M_\odot$	3.17 ± 0.07
$M_B/M_\odot$	3.07 ± 0.07
$\pi_{orb.}$ /mas	18.05 ± 0.17
Radius /$R_\odot$	2.32 ± 0.18
log g	4.21 ± 0.07
Luminosity (primary) /$L_\odot$	100.6 ± 4.3
Luminosity (secondary) /$L_\odot$	87.4 ± 3.3



Radial velocities from Hubrig et al. (2012) for components A (circles) and B (plus symbols) with the solid line showing the orbital model for A and the dashed line for B. The lower panel shows the fit residuals.