Are the dust and gas mass-loss rates from Miras reduced by the third dredge-up?

Stefan Uttenthaler (University of Vienna, Austria)
stefan.uttenthaler@univie.ac.at

ABSTRACT We recently presented evidence that Miras that show the third dredge-up (3DUP) indicator technetium (Tc) in their atmosphere have a lower *dust* mass-loss rate (MLR) than Miras at comparable pulsation periods but without Tc. This suggests that the dust MLR is reduced by the occurrence of 3DUP. Here we present further evidence in support of this finding. Most importantly, the available data of CO radio lines, although scarce for Miras without Tc, suggests that also the *gas* MLR is reduced by the 3DUP. Possibly, this finding teaches us an important lesson about connections between 3DUP, pulsation, and the ML mechanism of AGB stars.

INTRODUCTION In 2013, we reported the existence of two separate sequences of Miras in the K-[22] vs. pulsation period diagram if a distinction is made for the presence of Tc [3]. The K-[22] colour is a measure of the dust MLR, while Tc is an indicator of recent or ongoing 3DUP. Surprisingly, at a given period, the Tc-poor Miras (no 3DUP) appear to have a higher MLR than Miras with Tc. This is counter-intuitive to expectations from simple evolutionary considerations. In the present study we analyse the statistical significance of the previous finding and investigate whether the same relation is also true for the gas MLR, measured from CO radio lines.

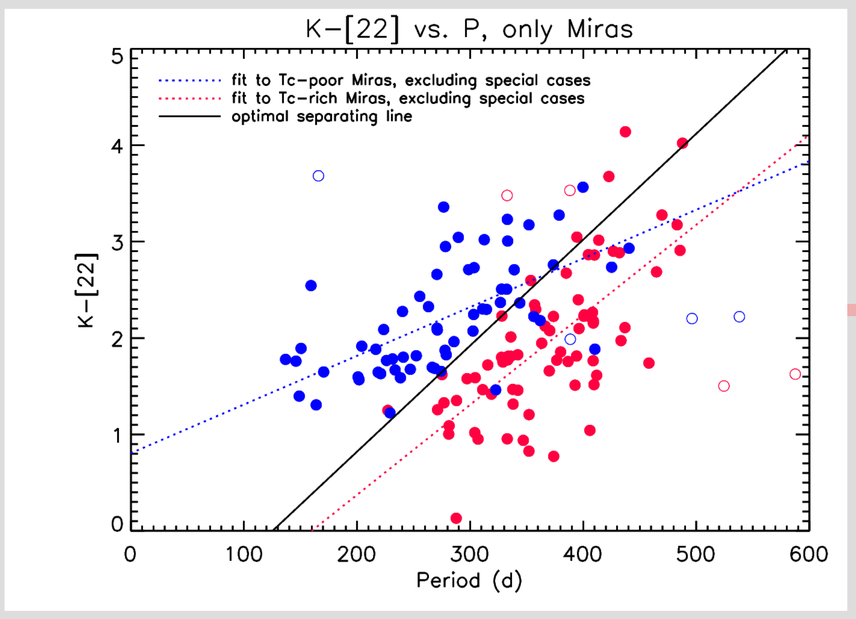

Fig. 1: *Dust MLR, measured by K–[22], as a function of period for Miras without Tc (blue) and Miras with Tc (red) [3]. The dotted lines show linear least-square fits through the two groups. The black solid line is the line that best separates the two groups.*

STATISTICAL SIGNIFICANCE Figure 1 shows the distribution of Miras w/o Tc (blue) and with Tc (red). This has been updated with objects from the X-shooter library [1]. It is evident that the two groups form separate sequences, where in a large range of periods the Tc-poor Miras have a *redder* K–[22] colour (higher MLR) than the Tc-rich ones. We computed the straight line that best separates the groups (solid line). Figure 2 shows the distribution of the difference to this line, denoted δ(K–[22]), restricted to only M- and MS-type Miras. A KS test shows that the probability that both groups are drawn from the same parent distribution is only 3×10^{-10}. The probability is even lower if no restriction to spectral type is made. It is highly likely that the two groups have different ML properties.

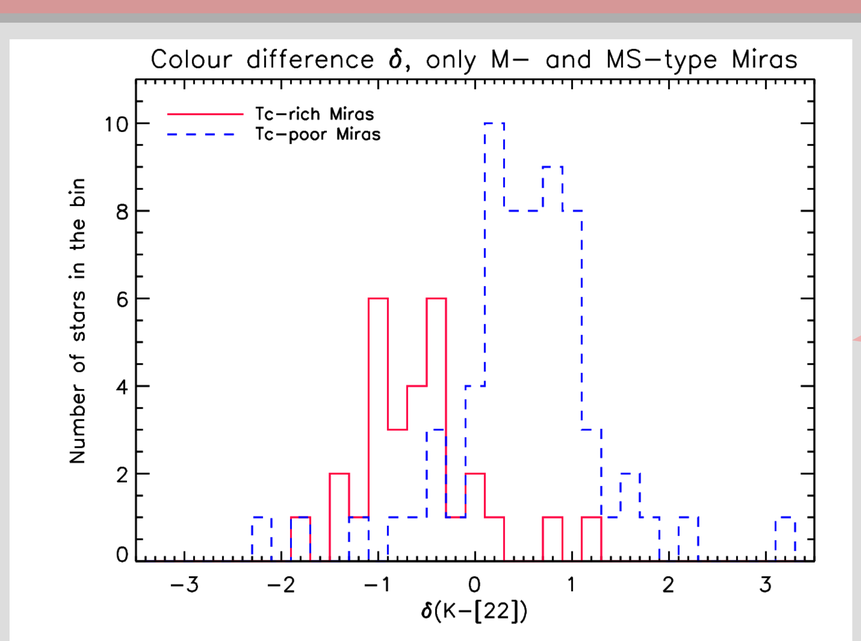

Fig. 2: *Distribution of difference in K–[22] to the best separating line (solid line in Fig. 1) between Tc-poor and Tc-rich Miras of type M and MS. The two distributions are highly significantly different.*

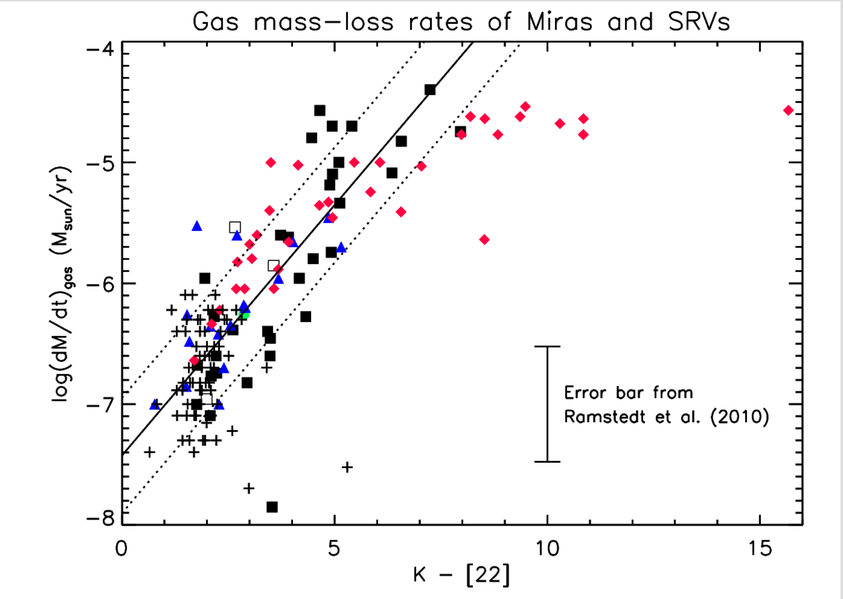

Fig. 3: *Gas MLR as a function of K–[22], a measure of the dust MLR. Pluses: SRVs; black open squares: M-type Miras w/o Tc; black filled squares: M-type Miras with Tc; blue triangles: S-type Miras; red diamonds: C-type Miras.*

THE GAS MASS-LOSS RATE It is interesting and important to see if this finding also holds for the gas MLR. This quantity can be inferred from CO radio observations. These data were collected from the literature and plotted as a function of K–[22], the dust MLR, in Fig. 3. The gas and dust MLR are well correlated.

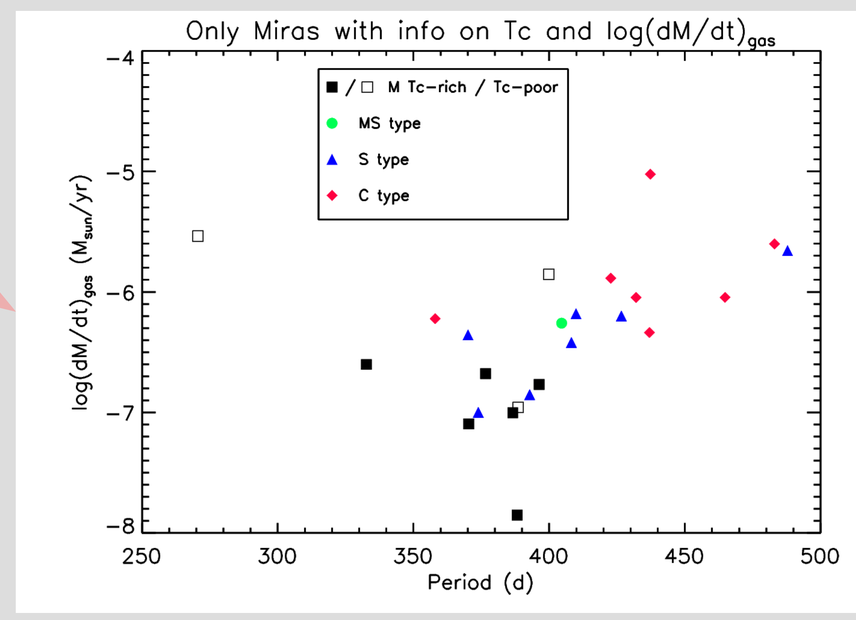

Fig. 4: *Gas MLR as a function of period for Miras with information on their Tc content, see legend.*

GAS MLR VS. PERIOD Figure 4 finally shows the gas MLR of Miras with information on Tc as a function of period. Unfortunately, only very few Tc-poor Miras have been observed to date to measure their gas MLR. One of the Tc-poor stars without Tc in Fig. 4 is W Hya, which may actually be an SRV rather than a Mira. The two other Tc-poor Miras, R Aql and RR Aql, both have a higher gas MLR than the Tc-rich Miras with comparable period. This suggests that also the gas MLR is higher in Tc-poor Miras or, to say it the other way round, **the mass-loss rate is probably reduced by the third dredge-up**. This has important consequences as also the life time on the AGB after 3DUP would be increased. Further observations are strongly recommended!

A paper on these findings is in preparation.

Discuss with me:

References:
[1] Chen et al., 2014, A&A 565, A117
[2] Ramstedt et al., 2008, A&A 487, 645
[3] Uttenthaler, 2013, A&A 556, A38