INSTABILITIES IN COLLIDING WINDS

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Abstract. The significance of radiative cooling for the stability properties of colliding astrophysical flows is shown. In the cases of WR ring nebula NGC 6888 and WR binary V444 Cyg it is found that thermal instabilities in the radiative loss function $\Lambda(T) \propto T^{\beta}$, $\beta = \beta(T)$ not only have an influence on the dynamics of the collision zone, but also that they lead to a quasi-periodic increase of the radiated energy.

Key words: stars: hydrodynamics – colliding flows – thermal instability – individual: V444 Cyg – NGC 6888

1. Radiative energy loss and stability

The energy loss due to radiative cooling can be approximated by the product of a radiative loss function $\Lambda(T)$ times a function of density. For the temperature range we are interested in the density dependence is quadratic and the radiated energy density per time is given by $dE_{rad}/dt = N^2\Lambda(T)$. Our calculations are based on the function $\Lambda(T)$ from Cook *et al.* (1989), using photospheric abundances. Around $3 \cdot 10^6$ K, line-cooling strongly sets in and $\Lambda(T)$ shows a thermal instability: with decreasing temperature cooling becomes more efficient. Also for other abundances and also in the case of a time-dependently calculated function $\Lambda(T)$ a thermal instability is present around $3 \cdot 10^6$ K (see, *e.g.*, Schmutzler & Tscharnuter 1993). Due to a thermal instability in $\Lambda(T)$, stored thermal energy in colliding flows can be radiated on a time-scale much shorter than any relevant hydrodynamical time-scale. For a more detailed treatment of radiative colliding flows we refer to Walder (1993).

2. NGC 6888

We chose the Wolf-Rayet ring nebula NGC 6888 as an example for the spherically symmetric case. The interaction zone where the wind of the central WR star hits the interstellar medium can be divided into several regions. However, for NGC 6888 only the leading part of this zone, next to the undisturbed interstellar medium, is of interest with respect to thermal instability. Here the temperature reaches about 10^6 K, the density is a few part./cm^3. In this leading part thermal energy is stored, due to the thermal instability described above, before most of it is radiated within a very short time. The leading part then vanishes before appearing again, storing again thermal energy which then will be released in the next energy outburst. Figure 1 shows the variable energy output of this leading part.

K. A. van der Hucht and P. M. Williams (eds.), Wolf-Rayet Stars: Binaries, Colliding Winds, Evolution, 525–526.

3. V444 Cyg

For the WR binary system V444 Cyg Stevens *et al.* (1992) have studied thin shell instabilities in 2D. Our 2D simulations of the same system now seem to indicate that also a thermal instability is present. After an initial cooling phase most of the interaction zone is cold. We then observe hot parts expanding again. After having reached their maximum extent they vanish again within approximately half an hour (see Figure 2). Most of their thermal energy is released on an even shorter timescale.

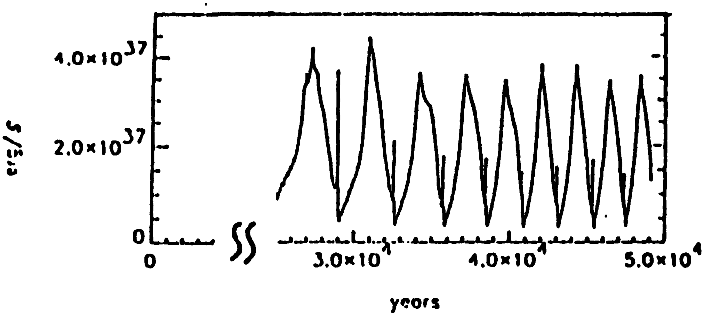

Fig. 1. Variable energy output of the leading part of the collision zone in NGC 6888.

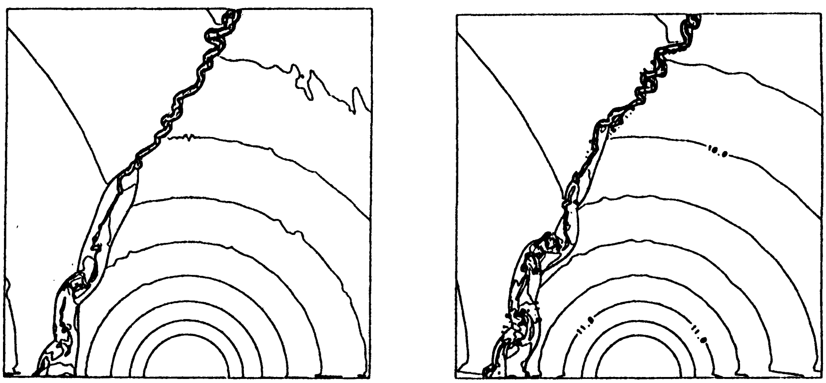

Fig. 2. Density contour plot of the system V444 Cyg. The right picture shows the system about 36 minutes later than the left one. Some hot parts have vanished within this time.

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