On the behavior of stellar winds that exceed the photon-tiring limit

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Stars can produce steady-state winds through radiative driving as long as the mechanical luminosity of the wind does not exceed the radiative luminosity at its base. This upper bound on the mass loss rate is known as the photon-tiring limit. Once above this limit, the radiation field is unable to lift all the material out of the gravitational potential of the star, such that only part of it can escape and reach infinity. The rest stalls and falls back toward the stellar surface, making a steady-state wind impossible. Photon-tiring is not an issue for line-driven winds since they cannot achieve sufficiently high mass loss rates. It can however become important if the star exceeds the Eddington limit and continuum interaction becomes the dominant driving mechanism. This paper investigates the time-dependent behavior of stellar winds that exceed the photon-tiring limit, using 1-D numerical simulations of a porosity moderated, continuum-driven stellar wind. We find that the regions close to the star show a hierarchical pattern of high density shells moving back and forth, unable to escape the gravitational potential of the star. At larger distances, the flow eventually becomes uniformly outward, though still quite variable. Typically, these winds have a very high density but a terminal flow speed well below the escape speed at the stellar surface. Since most of the radiative luminosity of the star is used to drive the stellar wind, such stars would appear much dimmer than expected from the super-Eddington energy generation at their core. The visible luminosity typically constitutes less then half of the total energy flow and can become as low as ten percent or less for those stars that exceed the photon-tiring limit by a large margin.

Reference: MNRAS
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/0812.0242

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