On the stability of radiation-pressure-dominated cavities

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Context:
When massive stars exert a radiation pressure onto their environment that is higher than their gravitational attraction (super-Eddington condition), they launch a radiation-pressure-driven outflow, which creates cleared cavities.
These cavities should prevent any further accretion onto the star from the direction of the bubble, although it has been claimed that a radiative Rayleigh-Taylor instability should lead to the collapse of the outflow cavity and foster the growth of massive stars.

Aims:
We investigate the stability of idealized radiation-pressure-dominated cavities, focusing on its dependence on the radiation transport approach used in numerical simulations for the stellar radiation feedback.

Methods:
We compare two different methods for stellar radiation feedback: gray flux-limited diffusion (FLD) and ray-tracing (RT).
Both methods are implemented in our self-gravity radiation hydrodynamics simulations for various initial density structures of the collapsing clouds, eventually forming massive stars.
We also derive simple analytical models to support our findings.

Results:
Both methods lead to the launch of a radiation-pressure-dominated outflow cavity.
However, only the FLD cases lead to prominent instability in the cavity shell.
The RT cases do not show such instability; once the outflow has started, it precedes continuously.
The FLD cases display extended epochs of marginal Eddington equilibrium in the cavity shell, making them prone to the radiative Rayleigh-Taylor instability.
In the RT cases, the radiation pressure exceeds gravity by 1-2 orders of magnitude.
The radiative Rayleigh-Taylor instability is then consequently suppressed.
It is a fundamental property of the gray FLD method to neglect the stellar radiation temperature at the location of absorption and thus to underestimate the opacity at the location of the cavity shell.

Conclusions:
Treating the stellar irradiation in the gray FLD approximation underestimates the radiative forces acting on the cavity shell.
This can lead artificially to situations that are affected by the radiative Rayleigh-Taylor instability.
The proper treatment of direct stellar irradiation by massive stars is crucial for the stability of radiation-pressure-dominated cavities.

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Comments:

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