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Line-Driven Ablation of Circumstellar Disks

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Abstract. Mass is a key parameter in understanding the evolution and eventual fate of hot, luminous stars. Mass loss through a wind driven by UV-scattering forces is already known to reduce the mass of such stars by $10^{-10} - 10^{-4}$ $M_\odot$/yr over the course of their lifetimes. However, high-mass stars already drive such strong winds while they are still in their accretion epoch. Therefore, stellar UV-scattering forces will efficiently ablate material off the surface of their circumstellar disks, perhaps even shutting off the final accretion through the last several stellar radii and onto a massive protostar. By using a three-dimensional UV-scattering prescription, we here quantify the role of radiative ablation in controlling the disk's accretion rate onto forming high-mass stars. Particular emphasis is given to the potential impact of this process on the stellar upper mass limit.

Keywords. accretion, accretion disks; circumstellar matter; stars: formation; stars: mass loss

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Main sequence massive stars are known to drive strong mass loss through the interaction of their UV-photon flux with spectral lines from metal ions. Due to the extreme optical depth of these spectral lines, this interaction is only possible in the case where the lines are Doppler shifted out of their own shadow, for instance by the spherically expanding outflows of massive star winds. While an orbiting circumstellar disk, such as those found during star formation, does not have these same large-scale velocity gradients in the radial direction, Keplerian shear in the disk creates velocity gradients of similar magnitude and line-of-sight variation along non-radial directions. This similarity in scale and morphology of the non-radial line-of-sight velocity gradients through a disk to the radial line-of-sight velocity gradients through a wind implies that an orbiting disk should feel a force comparable to that which launches the stellar wind.

To test this, we use the hydrodynamics code, PLUTO (Mignone *et al.*, 2007, ApJS, 170, 228; 2012 ApJS 198, 7). We have added a three-dimensional UV line-driving prescription following the Cranmer and Owocki (1995, ApJ, 440, 308) extension to Castor, Abbott, and Klein (1975, ApJ, 195, 157). Results from our first paper in the series (Kee *et al.* 2016, MNRAS, 458, 2323) show that the removal of material from a continuum optically thin circumstellar disk, such as might be found in a Classical Be star system, occurs at approximately the spherically symmetric wind mass loss rate. First results for disk densities more comparable to those found in star forming environments show that this basic scaling holds up, with at most a very weak scaling of ablation rate with disk mass. Further work will continue to investigate this effect including additionally the accretion rate of the star forming disk to directly test whether the removal of mass from a star forming disk could play a role in modifying, or perhaps even halting, the flow of material onto a forming star.