Effect of Dust on Lyman-alpha Photon Transfer in Optically Thick Halo

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We investigate the effects of dust on Ly{\alpha} photons emergent from an optically thick medium by solving the integro-differential equation of the radiative transfer of resonant photons. To solve the differential equations numerically we use the Weighted Essentially Non-oscillatory method (WENO). Although the effects of dust on radia-tive transfer is well known, the resonant scattering of Ly{\alpha} photons makes the problem non-trivial. For instance, if the medium has the optical depth of dust absorption and scattering to be {\tau}a>>1, {\tau}>>1, and {\tau}>>{\tau}a, the effective absorption optical depth in a random walk scenario would be equal to \surd {\tau}a({\tau}a+{\tau}). We show, however, that for a resonant scattering at frequency {\nu}0, the effective absorption optical depth would be even larger than {\tau}({\nu}0). If the cross section of dust scattering and absorption is frequency-independent, the double-peaked structure of the frequency profile given by the resonant scattering is basically dust-independent. That is, dust causes neither narrowing nor widening of the width of the double peaked profile. One more result is that the time scales of the Ly{\alpha} photon transfer in the optically thick halo are also basically independent of the dust scattering, even when the scattering is anisotropic. This is because those time scales are mainly determined by the transfer in the frequency space, while dust scattering, either isotropic or anisotropic, does not affect the behavior of the transfer in the frequency space when the cross section of scattering is wavelength-independent. This result does not support the speculation that dust will lead to the smoothing of the brightness distribution of Ly{\alpha} photon source with optical thick halo.

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