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H$_2$ Lines from the First Generation Star Formation Process

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Abstract  Molecular hydrogen line photons emitted owing to formation events of first-generation stars and their detectability by future observational facilities are explored. The H$_2$ luminosity evolution from the onset of prestellar collapse to the formation of about 100 M$_{\odot}$ protostar is followed by a simplified model for the dynamical evolution. In particular, the calculation is extended not only the early phase of the runaway collapse but also to the later phase of accretion, whose observational feature has not been studied before. Contrary to the runaway collapse phase, where the pure-rotational lines are always dominant, during the accretion phase prominent emission is owing to rovibrational lines. Also, the maximum luminosity is attained in the accretion phase for strong emission lines. The peak intensity of the strongest rovibrational line reaches about 10$^{-27}$ (W/m$^2$), corresponding to the flux density of 10$^{-5}$ (µJy), for a source at the typical redshift of the next-generation infrared satellite, SPICA, Space Infrared Telescope for Cosmology and Astrophysics, is ideal for observing the redshifted rovibrational line emission, to exceed the detection threshold, about 10$^6$ such forming stars must reach the maximum luminosity simultaneously in a pregalactic cloud. Unfortunately, this situation is excluded by the current theoretical understanding of early structure formation.