Radiation Hydrodynamical Instabilities in Cosmological and Galactic Ionization Fronts

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The Cosmic Dark Ages ended with the formation of primordial stars 100 – 200 Myr after the Big Bang. Numerical simulations suggest that these stars formed in isolation and were very massive, 25 – 500 solar masses. With surface temperatures in excess of 100,000 K, primeval stars were extremely luminous sources of ionizing and Lyman-Werner photons and they created enormous H II regions of up to 30,000 light-years in diameter. We present three-dimensional radiation hydrodynamical calculations that reveal that the radiation fronts of these stars were prone to violent instabilities, enhancing the escape of UV photons into the early intergalactic medium and forming clumpy media in which supernovae later exploded [1]. The enrichment of such clumps with metals by the first supernovae may have led to the prompt formation of a second generation of low-mass stars, profoundly transforming the nature of the first protogalaxies. Cosmological radiation hydrodynamics is unique because radiation strongly coupled to both matter and primordial gas chemistry at early epochs, introducing a hierarchy of highly disparate time scales whose relative magnitudes can vary throughout a given calculation. We review the adaptive multistep integration scheme we have developed for the self-consistent transport of cosmological radiation fronts [2] and another application of it to the structure of galactic H II regions [3].

References

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