How do (massive) stars form?

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The sun was here way before humankind, hence nobody witnessed its birth. How did it happen? Star formation is a central brick in the galactic ecosystem, it gives initial conditions for planet formation and it is an active topic of research. I will present the current theory of star formation, then I will add a challenging ingredient: what about stars much (>8) more massive than the sun? Shouldn't it be even easier, due to their stronger gravitational field? One new character comes into play: the photon, and its radiative pressure. Massive stars start radiating while still accreting, and at a much higher luminosity as their mass increases. In a first simple 1D approximation their radiative pressure feedback can exceed the gravitational force and reverse the accretion flow. Spherical symmetry has been broken in multidimensional simulations, and disk accretion (2D) and Rayleigh-Taylor instabilities (3D) have emerged. Radiation must be treated accurately, in particular its frequency-dependent nature has to be captured because the gas-radiation coupling varies on orders of magnitude between the stellar photons (UV) and the medium photons (infrared), thus it strongly impacts its force and absorption by the surrounding gas. In my thesis, I have been coupling two radiative transfer methods in the RAMSES code: the first one is adapted to the direct stellar radiation (RAMSES-RT, M1) and the second one is a correct approximation for absorbed-and-reemitted radiation (Flux-Limited Diffusion). This hybrid approach brings big improvements for the gas temperature and the radiative force. I will present the impact of this approach in the formation of a massive star, and particularly the enhancement of radiative outflows. I will use a specific refinement strategy to observe the presence (or not) of these controversial Rayleigh-Taylor instabilities, and I will show how this result is of physical (and not numerical) origin. Finally, I will present preliminary outcomes when including magnetic field together with this method to investigate the origin (radiative or magnetic?) of outflows.