ON POPULATION III STAR FORMATION

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If primordial fluctuations were isothermal their amplitude at recombination would be non-linear on scales $M_O \simeq 10^{6\div 9}\ M_\odot$. Since the Jeans mass after recombination is $M_{JO} \simeq 8 \times 10^5\ \Omega^{-\frac{1}{2}}\ M_\odot$ the clouds of mass M_O would be able to form the first generation of compact objects, the so-called Population III. These clouds would acquire angular momentum via tidal interactions with their neighbours. The importance of rotation can be conveniently characterised by the spin parameter $\lambda = V_{rotation}/V_{free-fall}$ and tidal interactions lead to a spin $\lambda_O = 0.07 \pm 0.03$. As the cloud collapses λ increases as $r^{-\frac{1}{2}}$. Any fragment forming in a rotating cloud would have the same spin λ as the whole cloud. It could therefore collapse only by $\simeq \lambda_O^2$ in radius before centrifugal forces intervened, thus leaving a large geometrical cross-section for coalescence to be important. At radii $r \lesssim \lambda_O^{8/5} (M_O/M_{JO})^{2/15}\ r_O$ the coalescence time is shorter than the free-fall time and no fragmentation is possible below this radius. In the primordial clouds two major factors prevent fragmentation at larger radii. First, the background radiation is still 'hot' and the trapping of it would prevent fragmentation until the whole cloud has collapsed to a radius $10^{-2}\ x^{-2/3}\ r_O$. Here $x = 10^{-2}(M/10^7\ M_\odot)^{1/3}$ is the ionization fraction given by the balance between gravitational contraction and recombination cooling. Furthermore, any small density fluctuation would lead to fragmentation only after the paternal cloud had collapsed by a factor $(\delta/5)^{2/3}$ in radius. For these reasons fragmentation is unlikely until centrifugal forces halt the collapse and a disk forms. The disk will be initially at $T \simeq 10^4$K but after a small fraction of H_2 forms it will cool to $T_3 \simeq T/10^3\text{K} \simeq 1$ and the final fragments mass could be as low as $\simeq 0.2(\lambda_o/0.07)^4\ T_3^2 (M_{JO}/M_O)^{1/3}\ M_\odot$.

After the disk has fragmented the two-body interactions between stars will provide effective viscosity which would redistribute the angular momentum: the system will 'sphericalise' and evaporation of stars will begin. After some fraction of them have evaporated collisions between stars would become important and the likely outcome of it would be a formation of supermassive object (SMO). Thus, two different types of object would form: SMOs, and low-mass stars. We discuss the

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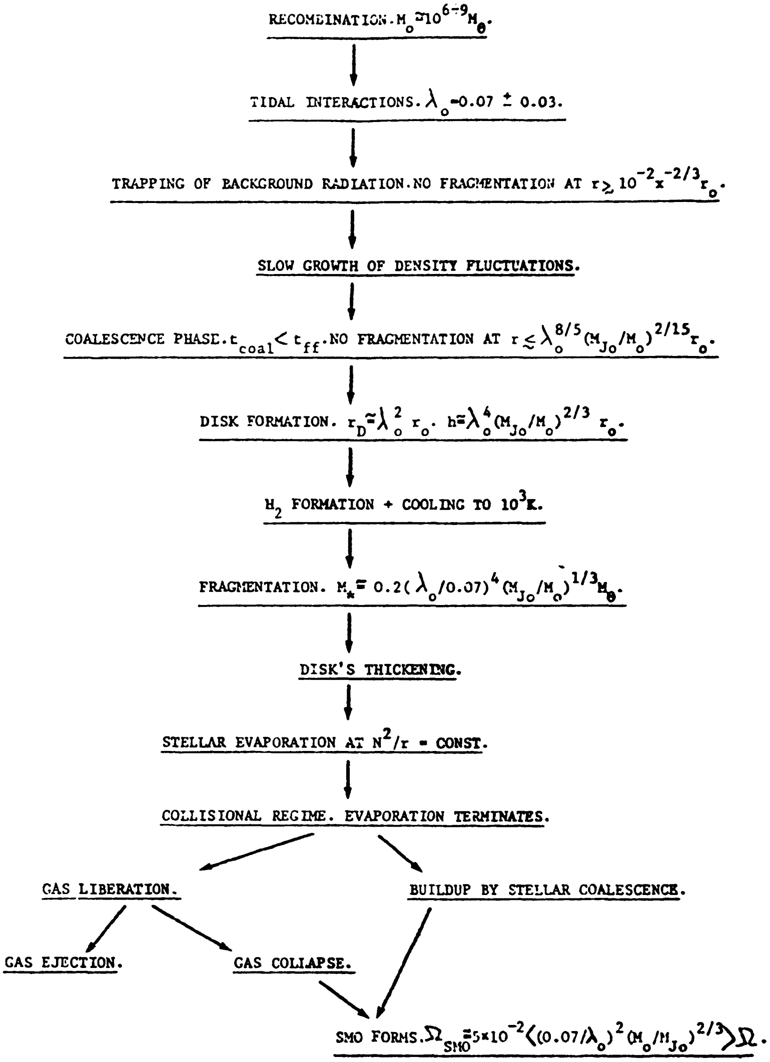
proportions of these constitutents in terms of M_o and λ_o, and consider whether clusters of low-mass Population III stars should survive.



The Figure illustrates the evolution of the Population III systems. Collisional regime will start once the velocity dispersion becomes comparable to the escape velocity V_e from the surface of the star, when the total mass left in the system is $(c_o/\lambda_o V_e)^2 (M_o/M_{Jo})^{5/3} M_{Jo}$ (c_o is the speed of sound at 10^4K). Since this is also the mass of the SMO that forms, the fraction of mass in SMOs would be $\Omega_{SMO}=0.05\ (0.07/\lambda_o)^2 (M_o/M_{Jo})^{2/3}\ \Omega$. The gas liberated in stellar collisions will be ejected from the system if the collisional luminosity exceeds the Eddington limit; otherwise the gas will be retained and will collapse to form SMO. All these processes along with the condition that most of the Population III systems lose their individual identity by the present epoch definedifferent regions on (λ_o, M_o) plane and we discuss them in more detail elsewhere (Kashlinsky and Rees in preparation).