Co-Evolution of Central Black Holes and Galaxies
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On the Origin of the Galactic Center S Stars

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Most, if not all, galaxies with a significant bulge component harbor a central supermassive black hole. In our own Milky Way Galaxy, a disk of stars at a distance $r \sim 0.05$–$1\,\mathrm{pc}$ orbits the radio source Sgr A* at the center. Stellar orbits show that the gravitational potential on a scale of $\sim 0.5\,\mathrm{pc}$ is dominated by a concentrated mass of $M_{\mathrm{BH}} \approx 3.6 \times 10^6\, M_\odot$, which is associated with a supermassive black hole. In addition to the black hole, the models require the presence of an extended mass of $(0.5 - 1.5) \times 10^6\, M_\odot$ in the central parsec, which can be explained well by the mass of the stars that make up the cluster. Thus, the Galactic center star cluster is composed of a central supermassive black hole and a self-gravitating disk that is several Gyrs old and comprised of late-type CO absorption stars. Significant disk rotation in the sense of the general Galactic rotation has been detected. This system is probably a strongly warped, thin single disk; the mean eccentricity of the observed stellar orbits in the disk is $e \approx 0.36 \pm 0.06$.

The disk also has more than 100 very young ($6 \pm 2\,\mathrm{Myr}$), massive, type O Wolf–Rayet stars. Another small group of roughly 20 type B stars with the orbital periods as short as 15 years ("S stars") that are found near ($< 0.05\,\mathrm{pc}$) the black hole follow eccentric ($0.3 \lesssim e \lesssim 0.95$), randomly oriented orbits. These early main-sequence B stars are young, with an estimated age of $< 10\,\mathrm{Myr}$. To reiterate, two key properties of the S star orbits are their random orientations and their high eccentricities.

The origin of the rotating stellar disk can be understood. Indeed, an orbiting gas cloud would dissipate energy and the gas would settle into a thin protodisk. The disk radiates heat from its surface, and therefore cools down and becomes thinner and thinner. Subsequently, as a result of local Jeans gravitational instability, on attaining a certain critical thickness that is small in comparison with the outer radius of the system R (and, correspondingly, very low temperature), the disk disintegrates spontaneously into a number of separate protostars. In contrast, the origin of young S stars so near the Galactic center is a puzzle, since molecular clouds would be unable to collapse and fragment in the tidal field of the massive black hole; star formation should be quenched by the strong tidal shear from Sgr A*.

To explain the S stars, I propose a model in which the stars formed originally in the parsec-scale disk through Jeans gravitational fragmentation of gas. The newly formed S stars then migrated inward to the Galactic center via the torques exerted by Lin–Shu-type spiral density waves on the stars at an inner Lindblad resonance: the resonant wave–star mechanism might have removed the disk stars by redistributing them radially inward. The model explains both the number of observed S stars orbiting the Galactic black hole within the nuclear ($< 0.05\,\mathrm{pc}$) star cluster and a key property of the S star orbits, namely their high eccentricities. Abbreviated results have been reported by Griv (2009).

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Reference

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