Evolution of a Nuclear Gas Disk and Gas Supply to the Galactic Center

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Gas supply to galactic centers is important for activities in galactic centers and growth of super-massive black holes (SMBHs). To elucidate relation between gas supply processes to galactic centers and activities in galactic centers is also important for understanding the evolution of galaxies. We have studied the relation between gas supply from the Galactic disk to the central 60 pc region in our Galaxy and stellar and gas distribution in this region. A part of our study[1] was published by support of NAOJ. Here, we report the results of [1].

In the central 60 pc, there are three young massive star clusters (Central cluster, Arches cluster, and Quintuplet cluster). Each of the clusters contains a hundred of massive stars and masses of the clusters is estimated to be ~$10^4 M_\odot$, if we assume the Salpeter-type IMF[2]. The Central cluster exists within the central 1 pc and the other clusters exist at the projection distance of 30 pc from the Galactic center. How these clusters are formed remains unclear. At the radius of 2–5 pc, there is also a massive molecular gas ring called the circumnuclear disk (CND). Its mass is estimated to be $\leq 10^6 M_\odot$[3]. How the CND is formed and how the CND is related with the Central cluster are uncertain. The clusters have similar ages, indicating that the clusters are formed simultaneously by the same process. In [1], we consider the possibility that the CND and the star clusters are formed simultaneously by the evolution of a self-gravitationally unstable gas disk (hereafter, the nuclear gas disk) whose radius is much larger than the radius of the CND. We assume that gas is supplied from the Galactic disk to the nuclear gas disk continuously.

In order to investigate this possibility, we performed high resolution two-dimensional hydrodynamic simulations of the nuclear gas disk taking into account selfgravity and radiative cooling. All the simulations are carried out on Cray XT4 af CfCA of NAOJ.

The evolution of the nuclear gas disk is as follows. The outer part of the nuclear gas disk frist becomes self-gravitationally unstable by the gas supply from the Galactic disk. By self-gravitational instability, small gas clumps with the mass of $\approx 10^3 M_\odot$ are formed in the outer part of the nuclear gas disk. These gas clumps coalescences into more massive gas clumps. These massive gas clumps gravitationally interacts with each other and exchange their angular momentum. By this, angular momentum transfer is induced in the nuclear gas disk and gas is supplied to smaller radii. The typical mass of massive gas clumps are 10^4–$10^5 M_\odot$. We found that these massive gas clumps can reach the Galactic center without being destroyed by strong tidal force produced by the SMBH and the nuclear star cluster. Figure 1 shows the migration of a massive gas clump to the Galactic center.

Recently, low angular momentum cloud capture by the SMBH is proposed as the formation mechanism of the Central cluster[4]. They showed that in order to reproduce the observations, the mass of the gas clump must be comparable to 10^4–$10^5 M_\odot$. These masses are consistent with the mass of the gas clumps that migrate to the Galactic center in our simulations. Thus, the selfgravitational instability of the nuclear gas disk may explain the origin of gas clump assumed in[4].

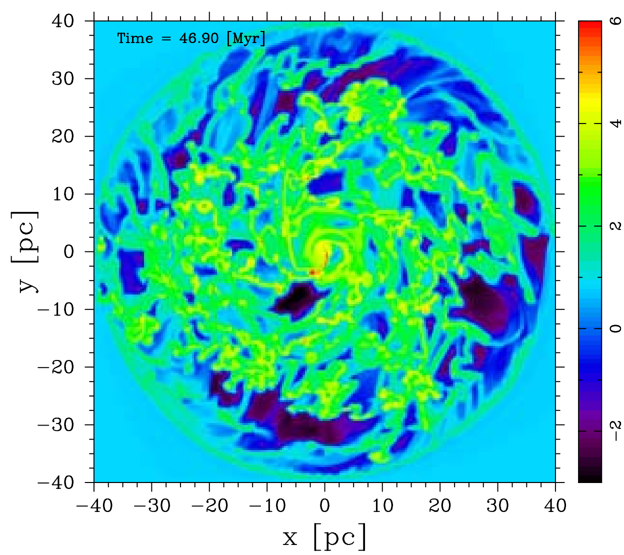

Figure 1: Migration of a massive gas clump to the Galactic center.

References

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