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ABSTRACT

In the first part of the dissertation, we approach the galaxy evolution from the viewpoint of chemical evolution. Although the chemical evolution is very powerful tool to check the plausibility of the proposed model of the galaxy evolution, the assumptions of the most of chemical evolution models are rather ad hoc (Chapter 1). We have to take into account the mechanism of structure formation to make models of chemical evolution. Thus, in Chapter 2, we study the chemical evolution of galaxies using a model for disk structure formation, the star-forming viscous disk model. We have studied the chemical evolution of star-forming viscous disks under the several physical conditions in relation to the possible processes of the disk formation, and compared with the observed gas and metallicity distributions of spiral galaxy disks to clarify as to whether the models, which are successful to explain the universal stellar luminosity profile, can also be applicable to the observed chemical properties. The main conclusions in this work are summarized as follows:

(1) In our models, we assumed the functional form of the kinetic viscosity as $\nu \sim \Sigma^a \Omega^{-b}$, where Σ is the surface density of gas and Ω is the angular velocity in the disk. The present disk models provide nearly universal distribution of gaseous abundance, except for the cases that the viscous coefficient dose not depend on the surface density of gas, i.e. for $(a, b) = (0, 2)$ and $(0, 3)$. These combinations of (a, b), giving null and positive abundance gradients, respectively, are abandoned in the light of the observed negative gradient in galaxies. The radial distribution of gas is also sensitively dependent on the form of viscosity and the cases of $(a, b) = (0, 2)$ and $(0, 3)$ are also rejected, though the dependence of the gas radial distribution on (a, b) is opposite to that of abundance.

(2) The models also predict the nearly universal relation between the gas mass fraction and the metallicity ($f_g - Z$ relation) in each radius. The predicted relation is rather similar to (but not the same as) that by the so-called simple model for chemical evolution. The comparison with the observed f_g - Z relations in spiral galaxy disks suggests that the model predictions are consistent with many galaxies including e.g. NGC598 and NGC2403. We classified such galaxies into Class A. However, there are some galaxies (e.g. NGC6946) for which the $f_g - Z$ relations are not reproduced by the viscous disk models. We classified

them in Class B. Inn the inner regions of such galaxies, the metallicity increases even if the gas mass fraction increases with decreasing radius.

(3) Both effects of the different $\beta = t_*/t_\nu$ and the gas infall from a halo changes the f_g - Z relation in the characteristic way; the allowable ranges for these quantities are $1/3 \leq \beta \leq 3$, and $T_{\mathrm{inf},0} \leq 4.6$ Gyr for metal-free infalling gas, where $T_{\mathrm{inf},0}$ is the infall time scale at the solar position. On the other hand, the fine structures of the rotation curve do not give any significant variations in the f_g - Z relation as long as the rotation is nearly flat.

(4) The detail comparison with the observations implies that the gas in the class A galaxies are dominated by neutral hydrogen gas in all radii, whereas the molecular hydrogen gas is dominant in the class B galaxies. We have found that adopting the conversion factor X for CO to H_2 as a function the metallicity does not remove the discrepancy between the model and observation of the class B. It is thus unresolved in the context of the standard viscous disk theory, and should be considered further in detail.

Therefore, we conclude that the chemical evolution of the star-forming viscous disk, which holds the physical basis from the theory of disk formation, is generally consistent with the chemical properties of the Milky Way and external disk galaxies – except the apparent discrepancy for molecular-gas dominated galaxies. For further understanding, it is thus necessary to consider the role of molecule formation and/or destruction in evolution of spiral galaxies.

In the second part of this dissertation, we report the ^{12}CO ($J = 1 - 0$) observation of post-starburst galaxies NGC4736 and 7331 (Chapter 3). Although the star formation is the most fundamental process in the galaxy evolution, we do not know the physics of star formation yet. To understand the properties of large scale star formation, the observation of ^{12}CO is very important, since the molecular clouds are known as the sites of star formation. The post-starburst galactic nuclei are special region where active star formation occurred about 5×10^8 years ago, though star formation is inactive now. Our main results and conclusions are summarized below.

(1) The two post-starburst nuclei of NGC4736 and NGC7331 have molecular gases of $M_{\mathrm{H}_2} \simeq 5 \times 10^7 M_\odot$ in their central region although they have no currently active star forming regions. The molecular gas surface densities of the two galaxies are comparable with those of normal S0 galaxies but lower by one order than those of starburst galaxies.

(2) Comparing the estimated molecular gas masses with the dynamical ones, we show that the gas disk is stable for gravitational instability in these nuclear regions. The star formation in these nuclei is prohibited by the deep underlying stellar potential sustained by the large galactic bulges although they have abundant molecular gas. These nuclei are in a phase of molecular gas accumulation after the past nuclear starburst.

(3) Considering the time scales of gas accumulation toward the center and the starburst and post-starburst evolution we have proposed the scenario of *intermittent nuclear starburst.*