Stellar species and evolution

3.5 Continuation of the chemical evolution of the galaxy

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3.5.4 Gas inflow and outflow and galaxy formation

The G-type correction problem shows that the assumptions of the simple model are unrealistic.
→ The reason is that gas containing metals flows in and out.

The gas originally had an initial metallicity of 0.2 solar masses. It is thought that chemical evolution occurred during the formation of the halo, and the increased metals fell into the disk.

When there is only gas leakage

Gas inflow rate F = 0

Gas outflow rate E ≠ 0

If E is proportional to the star formation rate at each time, then assume E = cψ(t).

$$Z = y\,\frac{1-R}{1-R+c}\,\ln \mu^{-1}$$

Z: Metal content (metal mass fraction)

y: Yield

Review: Yield is the amount of elements newly produced and released when a unit mass of gas is absorbed into a star.

R: Even if a star is formed, it quickly returns to gas and is recycled.

c: constant

μ: Proportion of gas contained in the system

If there is only gas leakage (continued)

Compared to the simple model, the yield is replaced by $y(1-R)/(1-R+c)$, and since c (a constant) is greater than 0, the effect of the original yield is reduced.

Effective Yield

Effective Yield is $y(1-R) / (1 - R + c)$

This would create more stars with lower metal content than the simple model.

→ That is, it can explain well the distribution of metals in stars with low metal content halos.

When there is only gas inflow

Gas inflow rate F ≠ 0
Gas outflow rate E = 0

⭐This is the opposite of when there is only gas leakage!
- assumption
Assuming that the inflow of gas with zero metallicity, Zf = 0, occurs so that the mass of the gas remains constant, (dMg/dt = 0) means that the ratio of the differentiated gas mass becomes zero.

F = (1 - R)ψ

Gas inflow rate = (1 - recycled gas) * star formation rate
e is the rate at which gas is released from stars into interstellar space by stellar winds and supernova explosions.
At this time

$$Z = y\left(1 - e^{-M_s/M_g}\right)$$

Metallicity = Yield * (1 - Rate of gas escape from star to interstellar space - Star Mass / Gas Mass)
As star mass/gas mass increases, metallicity approaches yield.

When there is only gas inflow (continued)

Let S be the cumulative metallicity distribution of the stellar system.

Consider the case where S is smaller than the metallicity Z.

$$S\ (< Z) = \frac{\ln(Z - y)/(-y)}{\ln(Z_1 - y)/(-y)}$$

Cumulative metallicity distribution of stellar systems with metallicity less than Z = (natural log (metallicity - yield) / - (yield)) / (natural log (metallicity of I - yield) / (-yield)
This means that the rate of producing stars with high metallicity is higher than in the simple model.

This is because the numerator and denominator have negative yields.
Thanks to the inflow of gas, even when the gas becomes metallic, there is still gas available to form new stars.