THE EVOLUTION OF THE GALAXY: THE ^{16}O GRADIENT AND THE SURFACE GAS DENSITY

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ABSTRACT: A series of simple analytical models for the evolution a galactic disk have been constructed. General solutions can be obtained under the assumption of pure radial gas flows, a star formation rate proportional to the n^{th} power of the surface gas density, a constant IMF, and the instantaneous recycling approximation. Models with small radial flow velocities in the range 0.05 to 0.1 km s^{-1} and an initial exponential surface mass density can reproduce, for galactocentric radii larger than about 5 kpc, the Galactic ^{16}O abundance gradient and the present surface gas distribution.

1. Model Assumptions

The evolution of a two-component (gas and stars) galactic disk with a fixed total mass can be solved analytically. The radial distribution of mass in stars is coupled to the gas surface density distribution, $\sigma(r)$, via a power-law star formation rate, σ^n. The continuity equation, with a pure radial velocity term without infall, is then solved in a closed form. For the case of the Galaxy, the initial surface mass density is assumed exponential, with a scale length of 5 kpc, and with a hydrogen mass abundance $X = 0.75$ and null metallicity, $Z = 0$. The radial gas flow is assumed position-dependent, $v(r)$, but has no explicit time dependence. Also, the initial mass function is assumed constant during the whole evolution (either Scalo's IMF or Salpeter's IMF, with $x = 1.5$, and $m_l = 0.01$ M$_\odot$ and $m_u = 100$ M$_\odot$). The mass return and ^{16}O yields were taken from Köppen and Arimoto (1991), and the present age of the Galaxy is taken as 12 Gyr.

2. Results

The main results are as follows: *i*) The values of the exponent are bounded between $1 < n < 2.5$; for $n = 1$ there is no gradient and for $n = 2.5$ the SFR is outside the observed range (see Franco 1991). *ii*) For $n > 1$ and velocities proportional to either r^{-1} or to r, the gradient is produced by the initial surface density profile. For velocities that are constant or proportional to r, and bounded between 0.05 and 0.1 km s^{-1}, the main observational trends can be reproduced. *iii*) When the initial surface density is exponential, the star formation cutoff is important in the ^{16}O gradient but does not affect the final distribution of $\sigma(r)$.

References

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