Chemical Evolution of Galaxies & Stellar energy feedback

Stellar chemical production
Modeling chemical enrichment
Gas dynamics
Kinetic energy from stars

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Estimating the SFR

Because the lifetime of massive stars are so short, their number count is proportional to the current SFR. So, how do we count the number of massive stars?

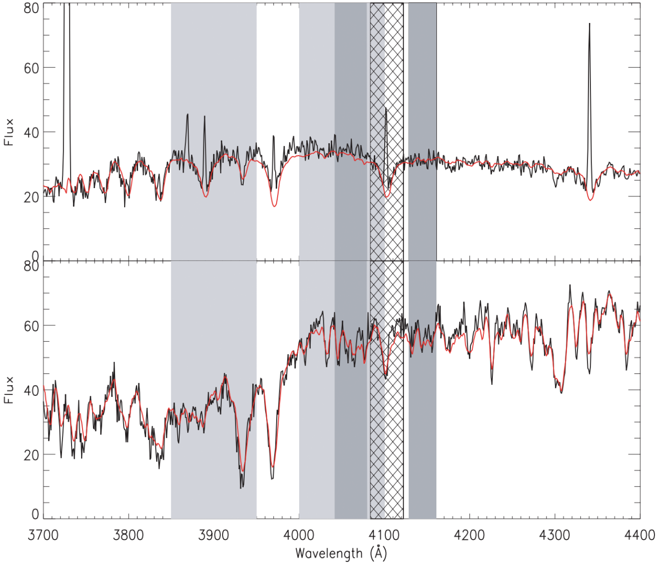
UV continuum: Most of the light from massive stars is in the UV.

Nebular emission lines: HII regions are produced by massive stars.

Forbidden lines: Available when the nebular emission lines are redshifted out of the visible part of the spectrum.

For starburst galaxies (where much of the stellar population is the same age), the FIR radiation from the dust can be used to estimate the number of massive stars.

Estimating M_* and SFH in a galaxy



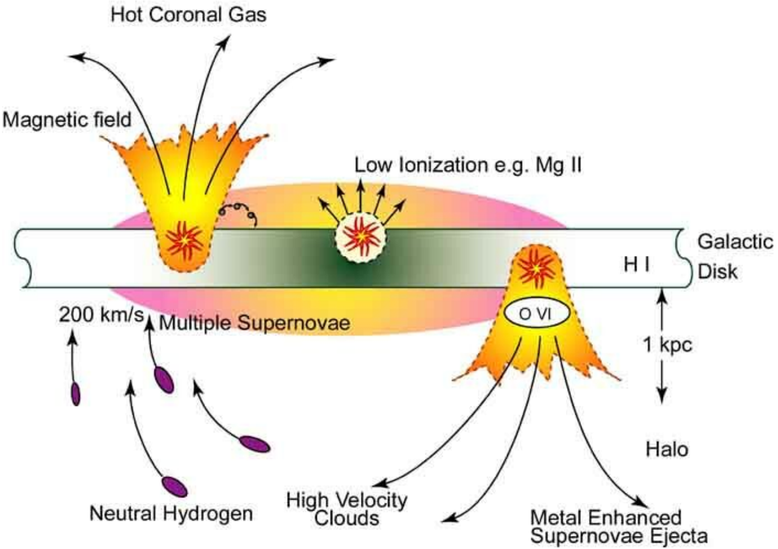
Stellar chemical production

Low-mass stars return most of their mass to the ISM during their final stages. Convection dredges up some of the heavy metals in the core so that they are also released.

High-mass stars enrich the ISM via stellar winds and core-collapse supernovae.

Type Ia SN convert C and O into iron-peak elements during explosion.

Galactic chemical enrichment



Closed-box model

No mass flow in or out of the system, so total mass is a constant.

$$M_{\text{tot}} = M_{\text{gas}}(t) + M_*(t) = \text{constant}$$

The gas mass evolves as

$$\frac{dM_{\text{gas}}(t)}{dt} = -\Psi(t) + \mathcal{E}(t)$$

where

$$\Psi(t) \equiv \text{ star formation rate}$$
$$\mathcal{E}(t) \equiv \text{ return rate}$$

Assuming that the ejected gas mixes uniformly with the ISM, then the metal evolution is

$$\frac{dZM_{\text{gas}}}{dt} = -Z\Psi(t) + \mathcal{E}_Z(t)$$

where $Z \equiv \frac{M_Z}{M_{\text{gas}}}$.

Closed-box model

Assuming instantaneous recycling, the gas-phase metallicity is

$$Z(t) = Z(0) + y_Z \ln\left(\frac{M_{\rm gas}(0)}{M_{\rm gas}(t)}\right)$$

where y_Z is the metal yield.

If all the mass is initially in gas, then

$$Z(t) = Z(0) - y_Z \ln \mu(t)$$

where $\mu(t) \equiv \frac{M_{\rm gas}(t)}{M_{\rm tot}}$.

Open-box model

Allowing gas flow in and out of the system results in

$$\frac{dM_{\rm tot}}{dt} = A(t) - W(t)$$

where $A(t)$ is the inflow rate and $W(t)$ is the outflow rate.

Then

$$\frac{dM_{\rm gas}}{dt} = -\Psi(t) + \mathcal{E}(t) + A(t) - W(t)$$

and (still assuming uniform mixing)

$$\frac{d(ZM_{\rm gas})}{dt} = -Z\Psi(t) + \mathcal{E}_Z(t) + Z_A A(t) - Z(t)W(t)$$

where $Z_A \equiv$ the metallicity of the inflowing gas.

Abundance ratios