Section 6: Ionization

AE435

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0 Intro

We can specify the state of a plasma via the species continuity equation:

State of Plasma

$$\frac{\partial n_i}{\partial t} + \nabla \cdot (n_i \vec{v_i}) = \sum_j \omega_{ij} \tag{1}$$

Where

$\frac{\partial n_i}{\partial t}$ is the rate of change of species i in the volume

$n_i \vec{v_i}$ is the convection rate for species i in or out of the volume

ω_{ij} is the net generation of species i in the volume due to process j

Previously, we had seen continuity as current but now we are considering species continuity. Note: the continuity is not equal to zero because we have species creation and destruction within the volume.

For instance, we could use

- **Electron-impact ionization:**
  - The rate at which species are being created via ionization $\omega_{i1} = k_1 n_e n_i$
- **Radiative recombination:**
  - The rate at which species are being removed via recombination. $\omega_{i2} = k_2 n_i$

And so on through all the processes seen in Chapter 5.

We could, in principle solve N equations for N species if we knew all the reaction rate constants k_j . For very simple, low-density plasmas, we use the corona model to do just that. For higher-density plasmas we have to use a collisional-radiative model, which is more general but requires lots of number-crunching and assumptions.

For really high density, the gas reaches equilibrium, and ionization modeling becomes much simpler and we use an equilibrium model. This model of equilibrium ionization will lead us to deriving the SAHA equation.