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Invited lecture

EXPERIMENTAL AND THEORETICAL DETERMINATION OF TEMPERATURE IN PLASMAS

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When plasma is in thermodynamic equilibrium, all species has the same temperature T. In practice, plasmas are generally not in equilibrium, so different temperatures can be obtained:

We define kinetic temperature for particles having a mass m and a velocity v distributed around v by the Maxwell law. Using the Boltzmann law, giving repartition in the different states of an atom, we obtain the excitation temperature T_{exc} and using the Saha equation, we derive the ionisation temperature. The electronic temperature T_e is obtained by the classical kinetic gas theory; using the ion mass instead of the electron mass we deduce the ionic temperature T_i.

Radiation temperature T_{rad} is obtained using the Planck law. In a complete thermodynamic equilibrium CTE, we have equality of all these temperatures ($T_{cin} = T_{exc} = T_{ion} = T_e = T_i = T_{rad}$). The electronic temperature Te can be obtained using spectral lines broadening. For example, when the Doppler effect is predominant, the width of lines is proportional to the square root of T_e. Using the hydrogen lines, we can found tables and empirical laws giving relations between widths and T_e for an electronic density condition of plasma.

Some authors use noble gas lines for determining T_e. The first common and useful behaviour law of the width is an inverse proportional law to the root square of temperature; this law was performed by a power one. But this can not be a general law, because in some lines, the width increase with temperature and more consistent laws are developed relating the temperature variation with the structure of the emitter.