Transport of Thermal Energy and its Relation to the Spontaneous Rotation Phenomenon*

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Abstract

An important process that is intrinsically connected to the transport of the plasma thermal energy is the "spontaneous toroidal rotation" of axisymmetric plasmas. This connection was pointed out first in the formulation of the so called accretion theory [1] and has been confirmed consistently by the most recent series of experiments [2] on this phenomenon. According to this theory, angular momentum in one direction is "accreted" on the material wall surrounding the plasma column [3] while angular momentum of the opposite direction (e.g. in the direction of the ion diamagnetic velocity in the case of the H-confinement regime) is carried from the edge toward the center of the plasma column by modes that are driven primarily by the plasma pressure gradient. We have verified that toroidal ballooning modes do not provide significant transport of net angular momentum. Thus toroidal "travelling modes", along the magnetic field, which instead can carry net angular momentum in the radial direction, have to be present and have significant amplitudes.

Two forms of the relevant quasilinear theory are derived identifying the ion pressure gradient as the driving factor for the angular momentum inflow and associating the sign of the ratio of the relevant poloidal to the toroidal mode numbers to that of the plasma toroidal velocity gradient. According to this analysis the source of the excitation of travelling modes is near the edge of the plasma column, from which the rotation velocity has been observed to enter, while the source of excitation of the ballooning modes is well within the plasma column where the ratio $\eta_i = d \ln T_i / d \ln n$ of the ion temperature gradient to the density gradient is maximum.

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[1] B. Coppi, Nucl. Fusion, **41**, 1 (2002).
[2] E. S. Marmar, et al., Fusion Energy 2002 (IAEA, Vienna) Paper OV/4-1
[3] B. Coppi, et. al., Fusion Energy 1998 (IAEA, Vienna) Paper IAEA-F1-CN-69-Th3/7.