Addendum to FLORA User's Manual: The FLORA equilibrium package is limited to weak rotation

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The FLORA code equilibrium calculation is currently limited to the case of weak rotation, by which it is meant that the perpendicular pressure summed over species is dominated by the thermal pressure components; and the plasma rotation contribution to the pressure is assumed small, $p_{\perp rot} \ll p_{\perp th}$. The generalization to finite or strong rotational pressure effects in the perpendicular pressure balance relation (summed over species) is

$$\frac{B^2}{2} + p_{\perp th} + p_{\perp rot}(B) = P(z) \tag{1}$$

The right side of Eq.(1) is just $\frac{B(vac)^2}{2}$, determined by the vacuum magnetic field. The parallel pressure balance equation is formally unchanged

$$p_{\perp} = -B^2 \frac{\partial}{\partial B}\left(\frac{p_{||}}{B}\right) \tag{2}$$

where the pressures have been summed over species and over thermal and rotational contributions. The quantities on the left side of (1) are all functions of flux and z, while the right side is only a function of *z*. The major change is the explicit dependence of $p_{\perp rot}$ on the magnetic field *B*, which changes the solution of Eq.(1) for *B* given models for $p_{\perp th}$ and expressions for $p_{\perp rot}(B)$. It is easy enough to use simple models for the thermal pressure and the rotational pressure such that Eq.(1) remains a polynomial equation for *B* as a function of flux and *z*, e.g., a bi-quadratic for *B*.

The condition for weak rotation when $T_i \geq T_e$ and the rotation is due to ExB rotation arising from a radial electric field can be rewritten as

$$c\frac{E_r}{B} \ll v_{thi} \;\rightarrow\; \frac{e\phi}{T_e}\frac{T_e}{T_i}\frac{\rho_i}{L_{\perp}} \ll 1 \tag{3}$$

where $E_r \sim -\frac{\phi}{L_{\perp}}$, v_{thi} is the ion thermal velocity, and ρ_i is the ion gyro radius. The inequalities in Eq.(3) are easily satisfied in many plasmas of interest and for all applications in which FLORA was used in the 1980s. However, relatively cold plasmas with strong rotation can also be of interest, in which case the FLORA equilibrium solver must be modified.