A bifurcation of the magnetic-axis due to the finite beta effect is studied by using the HINT code \(^1\). This computational method is performed by using the time-dependent relaxation technique for finite beta stellarator equilibria with no net current. The HINT computation is constructed by the following two step schemes.

**Step 1:**
\[
\frac{\partial p}{\partial t} = B \cdot \nabla v_s, \quad (1)
\]
\[
\frac{\partial v_s}{\partial t} = B \cdot \nabla p \quad (B \text{ fixed}), \quad (2)
\]

**Step 2:**
\[
\rho_m \frac{\partial v}{\partial t} = -\nabla \left[p1 - \frac{1}{\mu_0} \left( BB - \frac{1}{2} B^2 1 \right) \right] + \nu \nabla^2 v, \quad (3)
\]
\[
\frac{\partial B}{\partial t} = -\nabla \times E
\]
\[
= \nabla \times (v \times B - \eta J), \quad (4)
\]
\[
\mu_0 J = \nabla \times B \quad (p \text{ fixed}), \quad (5)
\]
where \( v_s \) is the artificial parallel sound wave velocity, \( \nu \) is the viscosity, and \( \eta \) is the resistivity. In a steady state, eq.(4) is reduced to the Ohm's law;
\[
v \times B - \eta J = -E = \nabla \phi. \quad (6)
\]
If there is no loop voltage, then the scalar potential \( \phi \) is a single-valued function, and we have
\[
- \langle \nabla \phi \cdot B \rangle = 0 = \eta \langle J \cdot B \rangle, \quad (7)
\]
where \( \langle \ldots \rangle \) means the flux-surface-average operator. Thus, we can obtain stellarator equilibria with no net current.

If the central-beta, \( \beta_0 \), is negligible small, the magnetic structure is obtained as Fig.1(a). In this case, we have the profile of the rotational transform, \( \epsilon \), as in Fig.1(b). When the beta value is increased, the Shafranov-shift is appeared, and the Pfirsch-Schluter current localizes on the outside of the torus. Therefore, the rotational transform near the magnetic-axis is going to decrease with the beta value. Finally, the value of \( \epsilon \) touches zero, and a bifurcation of the magnetic-axis appears, because the O-point in the magnetic structure is changed to the X-point. We find the bifurcation of magnetic-axis as in Fig.2.

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References