## §6. Physical Mechanisms of Formation and 'Self-Healing of Magnetic Islands

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A comparative study is given of some of the computational and analytical results presently available for calculating pressure-induced magnetic islands in 3D equilibria of currentless stellarators. The main goal of this study is to clarify the dominant physical mechanism of island formation, either the 'local' (current sheets) or the 'global' (Pfirsch-Schlüter currents) effects of the plasma current. For this purpose, we examine the behavior of $D_R$ (the criteria for the local resistive interchange mode) and the Jacobian $\sqrt{g}_{mn}$ for results obtained by HINT for the self-healing case of Helias. We find the process can be consistently explained by the 'global' effect by supposing that the self-healing process originates from the property that the pressure-induced islands always have the same phase independent of $\beta$ ('fixed-phase' property). This property has been discovered numerically; the phase of the pressure-induced islands is determined independent of the phase of the vacuum islands. The field generated by global effects of the Pfirsch-Schlüter current profile integrated over the whole plasma volume appears to have a specific simple global spatial structure. A coupling of this global-structure field with the non-axisymmetric configuration results in the robust 'fixed-phase' property of the pressure-induced islands. Moreover, we analyze the consistency of the equilibrium on the rational magnetic surface 5/6 which exists in the Helias configuration for vanishing island thickness. We find that the plasma deforms itself so that the so-called Hamada condition, that $\int dl/B$ be constant on a rational surface, is satisfied with very good numerical accuracy when the island vanishes completely due to self-healing. The behavior described above for a Helias configuration occurs with the resistive interchange criterion being satisfied. The importance of the global effect is further confirmed by a computation for resistive-interchange unstable equilibria; we observe the similar process of the self-healing.

On the other hand, in order to elucidate the self-healing process, the earlier theory is extended to include a small vacuum island which may, in general, have different phases than pressure-induced islands. For a negative (stable) $D_R$ case, the extended theory predicts complete self-healing at a critical value of beta, when the vacuum perturbation and the perturbation caused by the Pfirsch-Schlüter currents are exactly out of phase. Beyond this critical value, the islands reappear but with a flipped phase. This behavior is consistent with the computational results.

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