§15. Helias-Heliac Hybrid Stellarator for Currentless Plasma Confinement

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It is recognized that one of the well-optimized stellarators is Helias for Wendelstein 7-X [1] from MHD equilibrium, stability, particle confinement, neoclassical transport, bootstrap current and divertor. Recently we find a new helical axis stellarator with characteristics of magnetic surfaces similar to Helias by developing a coil system similar to Heliac [2][3], which is called Helias-Heliac hybrid stellarator (HHHS) [4]. A highly modulated $\ell = 1$ helical coil with four field period (M=4) is placed in an axisymmetric field produced by the standard toroidal and vertical field coils as shown in Fig.1. Here the outer modulated $\ell = 1$ helical coil is placed on an axisymmetric chamber with a circular cross-section in order to produce magnetic well in the whole confinement region. Magnetic surfaces at three cross-sections are shown in Fig.2. This type of HHHS is also possible for M=3 and M=5. There are three parameters to control the magnetic configuration shown in Fig.2 ; γ_1 is ratio of toroidal magnetic field by the toroidal coils to that by the inner $\ell = 1$ coil, γ_2 is ratio of the outer $\ell = 1$ coil current to the inner $\ell = 1$ coil current and γ_3 is ratio of the vertical coil current to the inner $\ell = 1$ coil current. It is notable that the average radius becomes $a_{av} = 0.46m$ and $R_{av}/a_{av} = 5$ for $\gamma_2 = 0$. However, weak magnetic hill with maximum value of 3% appears in this case.

References

1) Grieger, G., et al., Phys. Fluids B4(1992)2081.

2) Alejaldre, C., et al., Fusion Technology 17(1990)131.

3) Hamberger, S. M., et al., Fusion Technology 17(1990)123.

4) Yokoyama,M., Nakamura,Y., Wakatani,M., Nucl. Fusion, 34(1994)288.

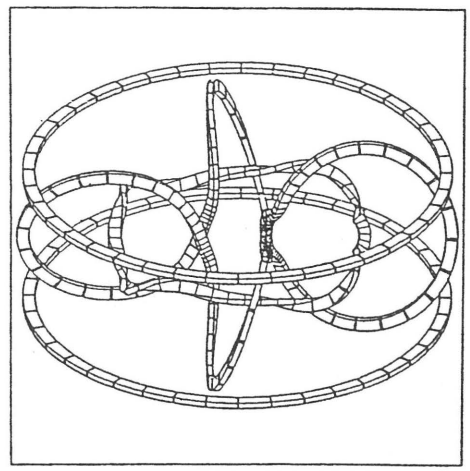

Fig.1. Coil configuration of M=4 HHHS. Toroidal coils are not shown here for simplicity. The inner $\ell = 1$ helical coil has winding law of $\theta - \pi = 4(\phi - 0.175 \sin 2\phi)$ and the outer $\ell = 1$ helical coil has $\theta = 4(\phi + 0.175 \sin 2\phi)$, where θ and ϕ are poloidal and toroidal angle, respectively.

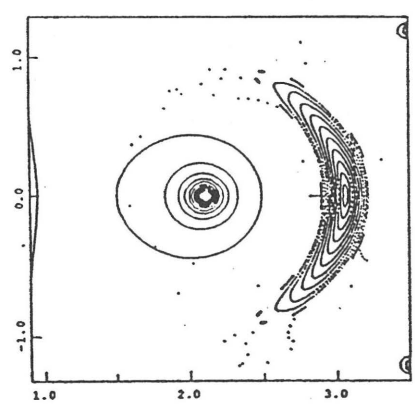

Fig.2. Cross-sections of magnetic surfaces of M=4 HHHS with $\gamma_1 = 0.5$, $\gamma_2 = -0.028/2.44$ and $\gamma_3 = -0.333/2.44$ at $\phi = 0$, $\phi = 2\pi/16$ and $\phi = 2\pi/8$. Here average major radius is $R_{av} = 2.3m$ and average minor radius is $a_{av} = 0.31m$. $|B|$ contours of the inner $\ell = 1$ helical coil with 2.44MA are also shown. $|B|$ at the magnetic axis is 0.546T at $\phi = 0$ and 1.405T at $\phi = 2\pi/8$.