Sustainment of stable spheromaks with imposed-dynamo current drive

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Inductive helicity injection current drive with imposed perturbations has led to the breakthrough of spheromak sustainment while maintaining stability. Sustained spheromaks show coherent, imposed plasma motion and low plasma-generated mode activity. Additionally, record spheromak current gain of 3.9 has been achieved with evidence of pressure confinement. The Helicity Injected Torus - Steady Inductive (HIT-SI) experiment studies efficient, steady-state current drive for magnetic confinement plasmas using a novel experimental method which is ideal for low aspect ratio, toroidal geometries and is compatible with closed flux surfaces. Analysis of surface magnetic probes indicates large $n = 0$ and 1 toroidal Fourier mode amplitudes and little energy in higher modes. Biorthogonal decomposition shows that almost all of the $n = 1$ energy is imposed by the injectors, rather than plasma-generated[1]. Additionally, much of the remaining nonaxisymmetric mode energy is part of the 3D equilibrium. Ion Doppler spectroscopy (IDS) measurements[2] show coherent, imposed plasma motion of ±2.5 cm in the region inside $r \approx 10$ cm ($a = 23$ cm) and the size of the separate spheromak is consistent with that predicted by Imposed-dynamo Current Drive (IDCD)[3]. Coherent motion indicates that the spheromak is stable and a lack of plasma-generated $n = 1$ energy indicates that the maximum q is maintained below 1 for stability during sustainment. Results from the HIT-SI3 experiment will also be presented. With three helicity injectors on one side of the flux conserver, the imposed mode spectrum can be varied to include $n = 2$ and 3 energy in addition to $n = 1$.

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[2] A. C. Hossack, Ph.D. thesis, University of Washington (2015).
[3] T. R. Jarboe *et al*., Nucl. Fusion **52**, 083017 (2012).