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Advances in the Principal Design of The Superconducting Toroid for the new International AXion Observatory (IAXO)

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Axions are amongst the most promising dark matter candidates in modern cosmology. IAXO, the International AXion Observatory, once established, will operate the most ambitious solar axions detector to date. The sensitivity of the IAXO detector to the axion-photon coupling is one order of magnitude beyond the limits of the current detector, the CERN Axion Solar Telescope (CAST).

Although having low mass and zero electric charge, axions can be detected by their conversion to observable photons when passing through a channel with a high magnetic field. Thus, the IAXO detector incorporates a high-magnetic field distributed over large volume to increase the conversion probability. Inspired by the ATLAS barrel and end-cap toroids, a new large superconducting toroid is being designed to provide the required magnetic-field.

The new toroid comprises eight, one meter wide and twenty one meters long, racetrack coils and its outer diameter is 4.1 m. The toroid produces a useful magnetic field of 2.5 T, while the peak field is 5.4 T, for an operating current of 12 kA. The stored energy is 660 MJ. The coils are wound with Al-0.1wt%Ni stabilized NbTi/Cu cables. The anticipated cryogenic load at the operating temperature of 4.5 K is 250 W.

Here, we describe the principal design of the toroid, including concepts for the cold mass, cryostat, supporting structure and the movement system. Recent developments, such as new cold mass supports design and induced forces, are reported as well. Conductor design and stability analysis are presented. The quench analysis confirms the safe quench protection scheme. The challenges and constraints on the cryogenics system are explained. Thermal loads are evaluated to assess the necessary cryogenic power. Lastly, a concept of a forced flow supercritical helium based cryogenic system is presented.

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