A Novel Faraday Cup: Designing, Printing, and Testing a Conductive Plastic Faraday Cup

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A Faraday cup is a conductive cup that serves as a plasma detector, catching the charged particles in a vacuum and measuring the particle flow rate. Due to its advantages in being simple, accurate, and robust, it has many applications: mass spectrometry, proton therapy, and space probes, such as in the 2024 Europa Clipper Mission. Since most detectors serving in space missions are often limited by weight, size, and cost, and due to recent advancements in plastic technology, we proposed to build a novel conductive plastic Faraday cup instead of metal. In order for the Faraday cup to have good performance, light weight, and a reasonably small size, we decided to use the standard polylactic acid (PLA) filament infused with multi-wall carbon nanotubes for conductivity. I carried out several conductivity tests and minimized the volume resistivity to 2.72 x 10^5 ohms. Using SIMION, an ion simulation software, I then designed a particular shape of the interior of the cup to minimize secondary electron noise and added the Einzel lens effect to maximize its sensitivity. Afterward, I 3-D printed a prototype within a given size (around 3.5 x 5 cm^2) and conducted lab tests with it in a vacuum by measuring the current with different guard ring voltages. Comparing our results to that of other Faraday cups, the two results show agreement and therefore our design is promising, and we hope to send a similar cup into space for further testing and to apply it in future space missions.

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