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Ion Acceleration and Substructure of Hall Shocks in the Big Red Ball[1]

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The non-stationarity of quasi-perpendicular collisionless shocks makes satellite observations of the earth's bowshock challenging. Repeatable laboratory experiments can test our understanding of the shock formation/reformation process in a simpler setting. A Hall-regime, high-beta ($\beta \geq 1$) theta-pinch collisionless shock experiment is performed on the Big Red Ball. A supersonic magnetic piston moves radially inwards at $30 - 100$ km/s, compressing the target plasma column ($T_e \simeq 2$ eV, $n_e \simeq 10^{18}$ m^{-3}, $B \simeq 0.5$ mT). The sound and Aflvén speeds ($c_s \simeq 15$ and $v_A \simeq 10$ km/s) are controlled by adjusting the plasma density and magnetic field. Together, the control over the drive and characteristic speeds enables a wide range of magnetosonic Mach numbers ($1 < M_{MS} < 10$). Several predictions of a Hall model (specular reflection of ions, parallel energization of electrons, out-of-plane Hall magnetic fields) are observed in the experiment. Cylindrical VPIC simulations are used to optimize the experiment, and independently reproduce the above experimental observations. Results from both the experiment and simulations, as well as comparison to other Hall-regime shock experiments, will be presented.

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