The Dynamic Quadrupole: Jars, Mars, and Stars

Dr. Rob Sheldon/Grassmere Dynamics LLC

The quadrupole is beginning to reveal its dynamic secrets in the lab, in interplanetary propulsion, and in active galactic nuclei or gamma-ray bursters. The signatures of quadrupoles as distinct from dipoles are rapid stochastic acceleration with bi-stable states, bipolar jets, and in the laboratory, plasma confinement. First, we discuss how quadrupoles are more effective than either dipoles or (dipolar) shocks in accelerating particles with reference to Earth's radiation belts, the heliopause generation of cosmic rays, and the likely source of galactic cosmic rays. In addition, quadrupoles are also regions with chaotic magnetic fields, which may provide another signature of quadrupole-heated particles. Second, we discuss how quadrupolar electric fields are generated from the first excited state of a magnetic dipole, which is itself a consequence of energy flow through a plasma. Thus rapid energy flow is naturally dissipated through a quadrupole with two bi-polar jets. Finally, we discuss the problem of magnetic confinement of dusty plasmas, and how quadrupoles provide superior confinement that may make dusty plasma nuclear fission possible. When this confinement is coupled with energy-flow and stochastic acceleration, we have the recipe for bistable states, or macroscopic "energy levels" of stellar or galactic "central engines". In conclusion, this talk is a plea to plasma theorists and cosmologists alike to leave behind their homogeneous and isotropic solutions and consider not just magnetic dipoles but quadrupoles, which have the potential to revolutionize the dynamics of equilibrium solutions.