Modeling Dust Aggregate Dynamics in Magnetized Plasmas with DRIAD code and PYSINDy.

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Abstract

Complex plasmas are composed of micron-sized dust particles that are suspended in a gas with low ionization levels. The charging of these dust particles occurs because of interactions with electrons and ions and is influenced by factors such as the temperature of plasma, the density of the gas, and the strength of electric fields. Magnetic fields also have an impact on the charging of dust particles and their subsequent behavior, but it is not well understood. The effect is contingent upon the levels of magnetization exhibited by various charged species present in the complex plasma. Even though current theories mainly concentrate on dust particles that are spherical in shape, practical situations, encountered, for instance, in experiments related to fusion and in astrophysical settings, often entail dust particles with irregular shapes. To bridge this knowledge gap, an examination into the charging mechanism of dust aggregates is undertaken. More specifically, we compare how aggregates become charged in scenarios where no magnetic field is present (B = 0 T) to situations where a magnetic field is present (0 T < B < 3.5 T). Our analysis considers the variation in the flow of electrons and ions towards specific points on the surface of the aggregate. The way charge is distributed across the aggregate's surface results in conflicting torques, ultimately influencing the orientation and movement of dust particles within the plasma medium. To address this dynamic, solving the rotational motion requires a numerical approach; however, this process can be simplified using a heuristic method with PYSINDy.

Numerical study of anisotropic potential distribution near dust chains in the Plasmakristall-4 dusty plasma

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Abstract

Dust particles in the Plasmakristall-4 (PK-4) facility on board the International Space Station have been found to form extended filaments in the presence of an external polarity-switched DC electric field. These filaments are aligned in the direction of the externally applied electric field. In the direction parallel to the electric field, the dust particles are strongly coupled and behave as a crystalline-like structure. On the other hand, there is a weaker coupling among particles in the direction across filaments (i.e. perpendicular to the electric field). Due to the presence of dust particles, the charge distribution in a plasma is modified, as well as the spatial distribution of the potential. This gives rise to regions of positive and negative potential which depend on the interparticle distance, plasma pressure, dust and ion densities and other properties. The anisotropic potential distribution observed in these dusty plasmas can be compared to numerical simulations to understand anisotropies in the interparticle interaction potentials in these systems. In this project we aim to obtain a model of the electric potential distribution which captures the effects of the anisotropic ion wakes derived from an N-body numerical simulation of the dust and ions for time-averaged and time-varying plasma conditions.

Investigation of plasma disruptions in the Compact Toroidal Hybrid (CTH) Device Using Machine Learning Classification Techniques

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Abstract

From space physics to fusion energy, laboratory plasma facilities can provide key understanding of the underlying physics. Improved data management and utilization of existing databases can speed discovery and engage colleagues with no access to lab facilities. Here we discuss the use of Machine Learning (ML) classification algorithms to investigate plasma stability and disruptions in the Compact Toroidal Hybrid (CTH) device at Auburn. We employ SINDy - a Sparse Regression based framework developed by Steven L. Brunton [1]. SINDy seeks to determine governing equations in a system by promoting sparsity, such that the resulting solution is comprised of only a few terms. CTH can produce both stellarator-like and tokamak-like magnetic field configurations, which allows us to investigate how three-dimensional magnetic field topology affects stability. To help access the entire CTH database, we are developing a set of routines that aim to convert the current tree-like data structure into ML-friendly tabular form. The goal is to incorporate these routines in MIT PSFC's disruption-py framework, which will allow for CTH data to be easily sharable with external users.

[1]- Brunton, Steven L.; Proctor, Joshua L.; Kutz, J. Nathan (2016-04-12). "Discovering governing equations from data by sparse identification of nonlinear dynamical systems". Proceedings of the National Academy of Sciences. 113 (15): 3932–3937. arXiv:1509.03580