Magnetically Coupled Solar Sails

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Autonomous assembly of spacecraft requires control of the relative position and attitude of flight elements in close proximity to each other. Contactless motion controllers and gimbals (CMC&G) that operate at distances on the order of a few centimeters from each other appears ideal for missions using solar sail propulsion.

Given the small acceleration provided by solar sails, the optimal size and mass distribution of the various components flows down from the requirements of the sail deployment system, and the methods used for maintaining the sails under tension. It follows that the mass of the supporting structures can be minimized if light weight low rigidity supports are used to distribute the mass of the bus and of the payload over the large area of the sail. Following this basic property of the sail propulsion, it appears that solar sails would benefit considerably from the development and testing of modular structures that can be assembled in space into large and loosely connected sail systems.

Solar sail experts on this team have for years studied the application of sails for various science and exploration applications. Various sail configurations, as well as various ways of connecting sails, booms, and bus elements with gimbals and gossamer structures were examined. Recently, the team realized that electromagnetic forces could be used to assemble spacecraft elements in orbit, to link them together in formation flight, and to control their attitude without being physically joined, as long as they remain in close proximity to each other (~10 cm).

In the past, scientific studies envisioned the use of very low TRL type I and type II superconductors for formation flying and flux pinning of spacecraft elements at distances of several meters. These studies focused on the deployment of long baseline astronomical interferometers. They overlooked the advantages that rare earth permanent magnets can offer when small systems need to be linked at short distances. Thus, they did not consider the need for a technology that would allow spacecraft elements to fly in very close proximity using rare earth magnets and solenoids.