Laboratory of Reaction Dynamics

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Stereodynamics of Chemical Reactions

Atoms, molecules, and molecular clusters have their own intrinsic shapes, or structures. When a reaction takes place, its reaction mechanism, rate of reaction and branching ratio are controlled by "which part" of the two colliding chemical species mutually stick together in order to form a new chemical bond. This important fact is called the "steric effect" in chemical reactions. We investigate the "steric effect" in a variety of chemical reactions involving environmental, cluster, and surface chemistry by using the novel method of orienting reactant molecules or atoms with electrostatic, magnetic hexapole fields, and/or aligning them with polarized laser light prior to the chemical reaction. We also determine the structures of newly synthesized clusters using this hexapole method. Our goal is to actively control chemical reactions by manipulating the steric effects that we discover.

Steric effects in absorption and reaction on surfaces under ultra-high-vacuum

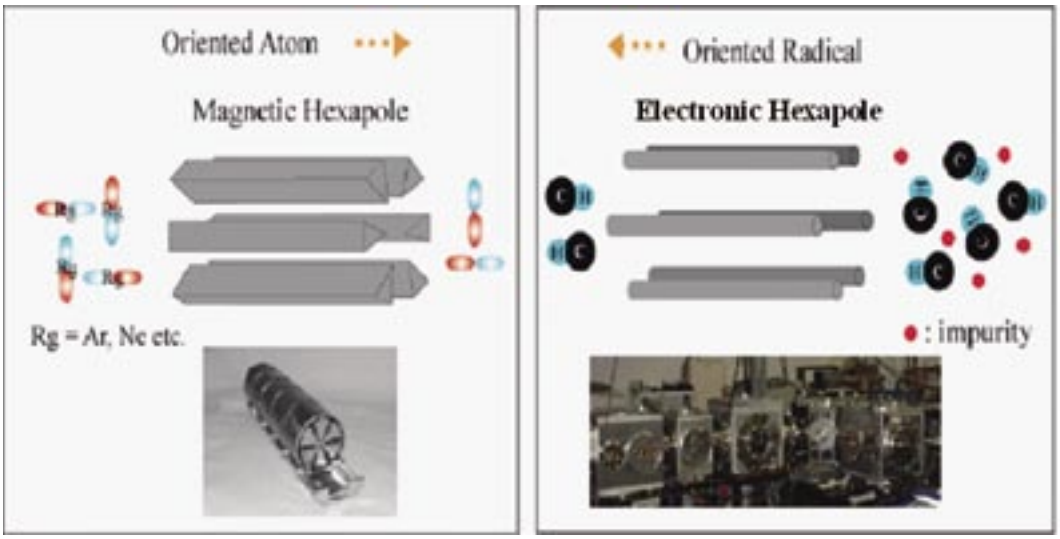
We have recently developed a new UHV-compatible oriented-molecular-beam machine, as shown in Figure 1. With this machine, a molecule coming in contact with a surface can be manipulated before surface adsorption. Thus, we can control the surface chemical reactions in order to fabricate new materials on the desired surface. We are also exploring a new catalytic activity of multi-component thin metal films or alloys based on the concept of "bottom-up chemistry". A variety of surface-science innovations are being developed in our laboratory.

Figure 1. New Machine for Surface Stereoodynamics

Dynamical stereochemistry of energy transfer collisions

Reactions of metastable noble-gas atoms with small molecules have long been of interest because of their diversity of reaction channels, and they therefore provide us with a new molecular-level concept of chemical reaction. Penning ionization consists of the spontaneous ionization of an intermediate collisional complex and, is therefore a process of fundamental importance in plasma research and astrochemistry.

Penning ionization can probe the electron density distribution of the orbital and determine which part of the molecule the electron has been removed, and the collision energy dependence of the ionization cross section is a good measure with which to clarify the anisotropy of intermolecular forces. Since the reactivity depends on stereo-anisotropic intermolecular forces, we therefore study how such a "steric effect" depends on collisional energy, as well as on the mutual orientation of reactants. Radical reactions are also one of the important subjects of research in this area.



We investigate the steric effect on gas-phase and surface reactions by using oriented molecules and atoms. Specific electronic and/or magnetic hexapoles are used in the prepartion of these molecules and atoms, as shown above.

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