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SHORT NOTE**Molecular Beam Scattering Apparatus
with Perfect Focusing Mass Spectrometer**

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A different type of crossed molecular beam apparatus coupled with the perfect focusing mass spectrometer¹⁾ is proposed. Conventional experimental methods of studying molecular beam collision processes used up to the present may be roughly categorized into two types according to whether they use the collision chamber technique²⁾ or the crossed beam technique³⁾. The former is more conventional than the latter and is customarily utilized where only the total cross section is needed. However, this method is in general inadequate for a measurement of precise collision processes, because the collision chamber contains target gases of appreciable pressure, the interaction point lies along the whole path of the primary beam and the resulting reaction products are suffused from multiple collisions with target gases. Their initial properties are altered before they are drawn out into the detection region. These disadvantages can be excluded by the use of the crossed beam technique where two primary beams cross at

a right angle. The colliding center is positioned definitely and the reaction products are unlikely to be subjected to further collisions except at the intersecting region. These instruments are indeed suited for precise measurements, the driving mechanisms are rather complicated and fairly expensive in construction.

In the present proposed device, on the other hand, there are important advantages over conventional ones. The perfect focusing mass spectrometer can be realized by a three dimensional quadrupole electrostatic field with an uniform magnetic field and may be of relatively simple construction and reasonable in cost. The ionic products which are formed at the colliding center and scattered into any solid angles with any energies are all refocused, with 100% efficiency, to the image point corresponding to their charge to mass ratio, since the device is endowed with both properties of perfect energy focusing and perfect angular focusing for a particle having the same charge to mass ratio⁴⁾. Even if

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Fig. 1. The trajectories of the ionic products XY^+ projected to the median plane. Other ionic products such as AXY^+ , AX^+ , AY^+ , X^+ or Y^+ are also focused to the respective imaging point. S: scattering point, D: imaging point, M, N: neutral beam source.

other kinds of ionic species exist, they are focused to the respective image point simultaneously (Fig. 1). The mass analyses as well as the measurements of total cross section can be carried out at the same time. The device would be powerful if applied to neutral-neutral reactions especially such an inelastic collision as Penning ionization process, where the struck molecule is ionized: $A^* + XY \rightarrow A + XY^+ + e^-$, the reaction between a metastable excited atom or molecule A^* and another reactant XY . In this case both of the primary beams, A^* and XY , are free of the electric charge, they are easily introduced into the spectrometer indifferently to the presence of the electric field and the magnetic field in the similar way as in the usual crossed beam apparatus^{5,6}. The differential cross section as well as the total cross section can be obtained by the use of a collimated detector, where no angular scanning of the detector is necessary.

The present device could be successfully applied as a photofragment spectrometer⁷ only by replacing one of the primary neutral beams with an intense light beam such as a laser. The basic concept is also applicable to an ion-neutral reaction, but in this case a primary ion beam must be produced inside the spectrometer and the resulted system will become somewhat complicated comparing with those above mentioned.

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