A CROSSED BEAM APPARATUS FOR CHARGE TRANSFER MEASUREMENTS

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In the last years an appreciable experimental effort has been devoted to the ion-atom low energy collisional range investigation. Charge transfer reactions have been studied also with particular interest and applications to astrophysics,ionospheric physics and plasma physics.In spite of the experimental and theoretical efforts, cross section parameters for many charge transfer reactions are still affected by large uncertainty.In the energy range 10-10^4 eV the experimental technique,which seems to permit the highest accuracy for cross section measurements,is the crossed beam technique,which was here used in the attempt to develope and improve new systems for the investigation of reaction mechanisms occuring in the interstellar mediu and in planetary atmospheres.Therefore a novel device was designed for charge transfer reactions in the energy range 20-200 eV and the system was adapted to the molecular beam apparatusa of universal type already constructed in Lecce (1).

Experimental set up:

The molecular beam apparatus and the ion source are described in detail in Ref.1 and 2.We will here summarize only the experimental procedure used for the noble gas reactions described below :
A supersonic beam,generated by a 100 micron quarz nozzle at a pressure of 50 Torr and at room temperature,is geometrically defined,after passing trough a skimmerby a collimator of 3 mm diameter and is chopped at a frequency of 35 Hz in order to allow lock-in measurements and to suppress background noise. The ion beam is generated by a Nier source and his shape (diameter 2 mm) in the scattering center id define by a diaphragm situated between ion source and reaction chamber.
The charge transfer reaction takes place in the center of the reaction chamber where two electrodes collect the primary ions and the transfer current; the second electrode has a potential of some volts with respec

to the grounded screen. The secondary current, which is generated by the transferred charges, is detected by an electrometric amplifier with a transfer-impedance of 10^{11} ohm, frequency adjusted by means of a zero-pole cancellation method. This amplifier is situated in the vacuum chamber directly on the secondary ions collector and is thermoregulated at a constant temperature of 60±1 °C in order to minimize the offset drift. The output voltage is amplified again by a r.m.s. lock-in-amplifier. The experimental conditions were: pressure in the scattering chamber: 10^{-6} Torr, pressure in the ionization chamber: 2.10^{-5} Torr, primary ions current: 5.10^{-8} A, electron energy in the ion source : 60 eV.

Results and future developments :

He + He^+, Ne + Ne^+, A + A^+, Kr + Kr^+ and Xe + Xe^+ resonant charge transfer reactions have been studied in detail and the cross sections versus collisional energy are plotted in Figs.1-5 in comparison with other experimental results and with theoretical computations made by Rapp and Francis (3). The relative abundance of primary atoms with multiple ionization at an electronic bombardment energy of 60 eV is (4) : 0.05 % for He; 0.25 % for Ne; 8% for A; 3% for Kr and 9% for Xe.
In the cross section calculations we considered only standard reactions as $A + A^+ = A^+ + A$. No assumption has been made on the primary ions excitation. The estimated error in the cross section determination is about 12% mostly due to the error in the scattering Volume uncertainty.
Because of the positive results achieved also in comparison with other groups, the future effort can be devoted to improve the ion beam source with addition of a mass selector at low resolution and to study resonant and non-resonant charge transfer processes between elements of particular interest for atmospheric physics (5,6) and astrophysics (7), including measurements of molecules excitation before and after collision.

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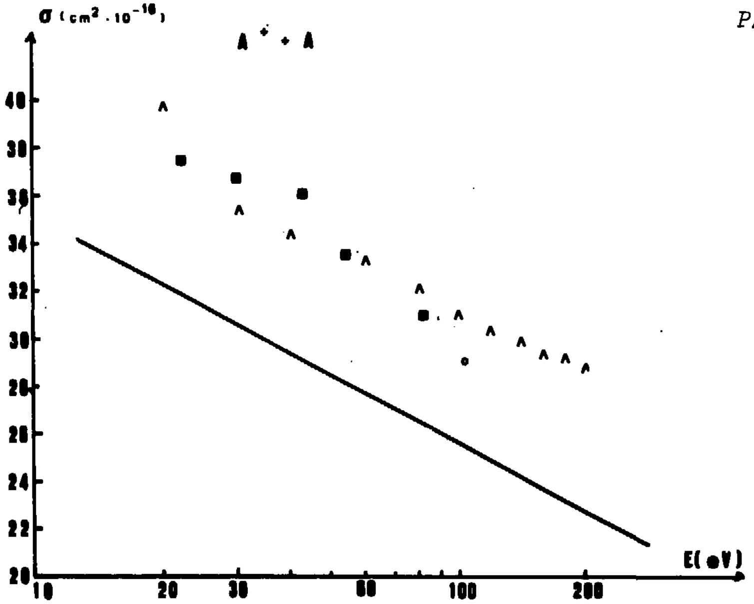

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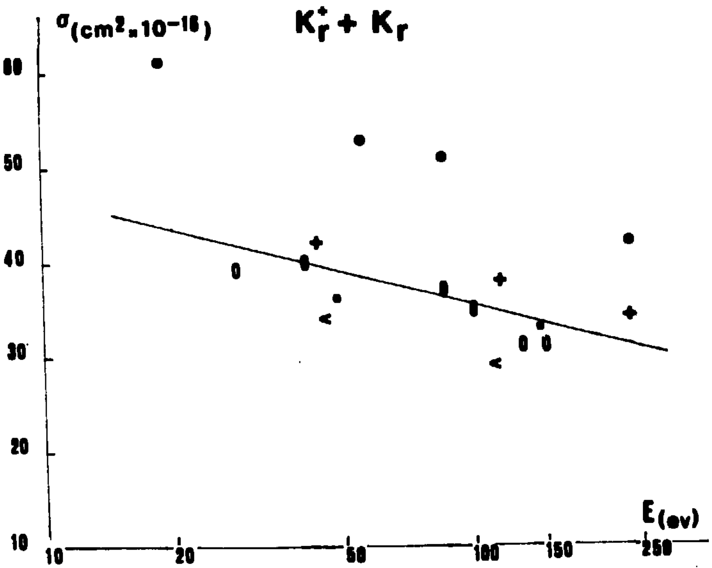
Fig. 1



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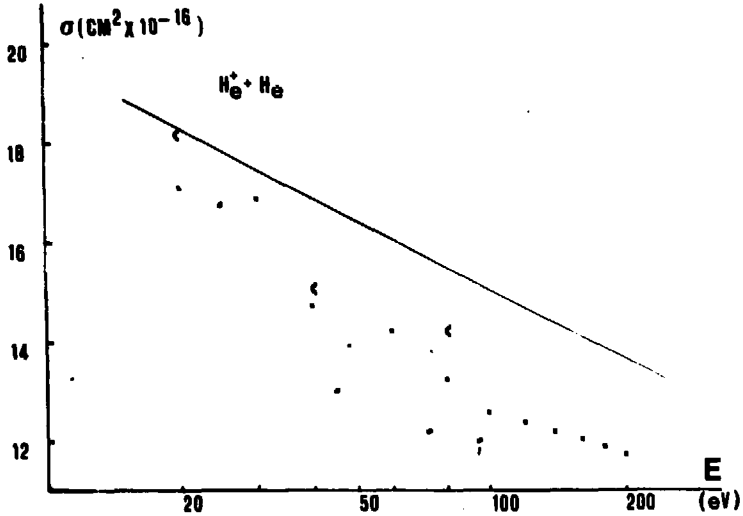
▮ Our measurements

Fig. 2



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▪ OUR MEASUREMENTS

FIG. 3

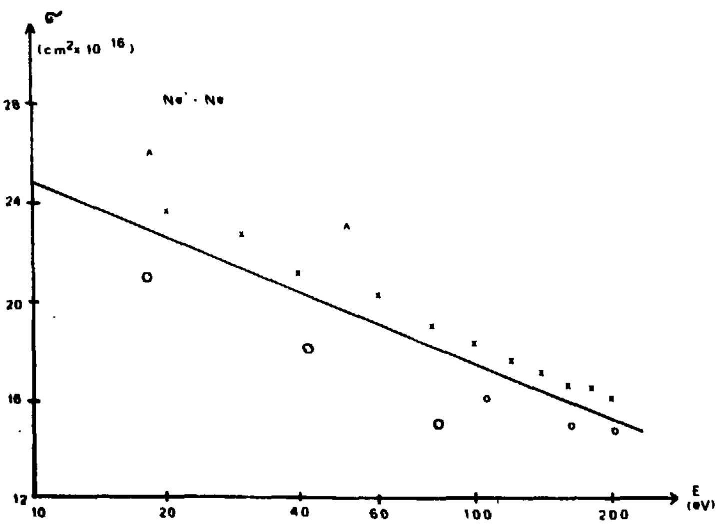

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FIG. 4

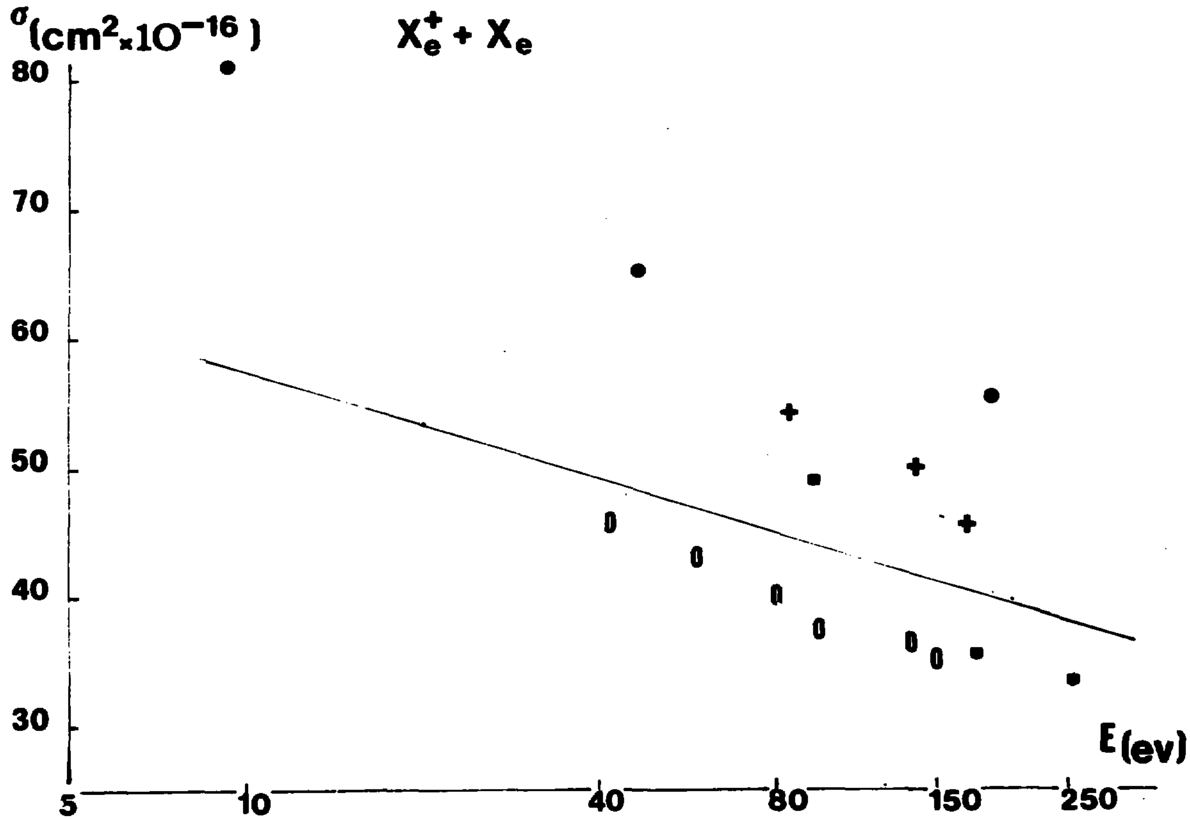

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Fig. 5