Chemi-ionization processes. Alkali-metal geocosmical plasmas

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chemi-ionization processes

attention will be paid on a group of ionization processes in excited and especially Rydberg atom (RA) collisions with ground state parent atoms, known in literature as chemi-ionization processes, namely

$$A^* + A^*(A) \rightarrow A_2^+ + e, \quad AI$$

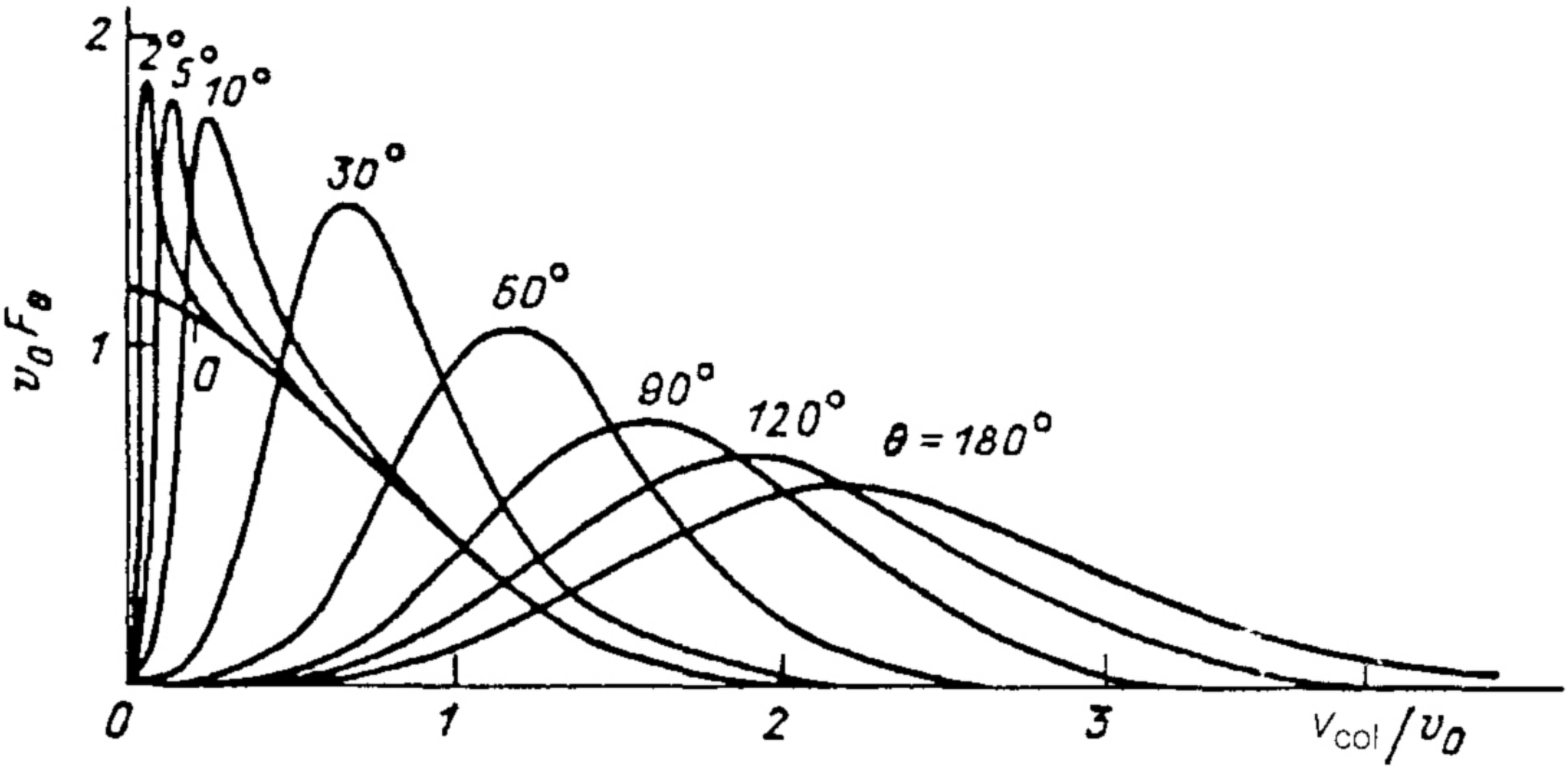
$$A^* + A(A^*) \rightarrow A^+ + A + e, \quad PI$$

AI rate coefficients for the process

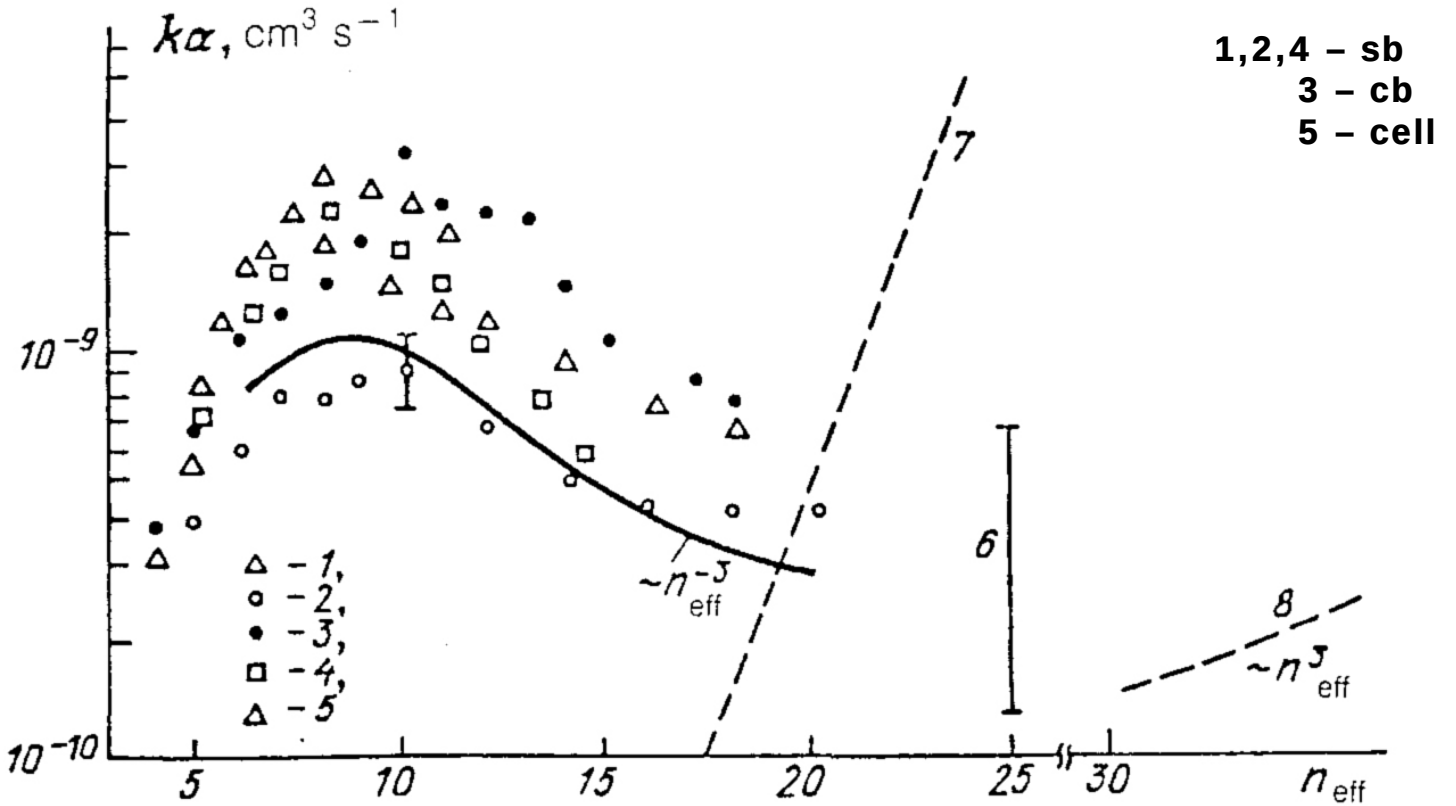
$$Na(3^2P) + Na(3^2P) \rightarrow Na_2^+ + e$$

Experimental conditions	Beam source temperature	Original value K, 10(-11) cm3/s
Gas cell, resonant lamp	550 K	3.8 (±20%)
Single beam, laser	580 K	0.015 (factor 2)
Gas cell, laser	650 K	0.56 (±40%)
Beams crossing at 90 degree, laser	520 K	0.34 (±50%)
Uncollimated single beam, laser	570 K	1.8 (±40%)

Relative-velocity distribution function for thermal beams of particles crossing at different angles

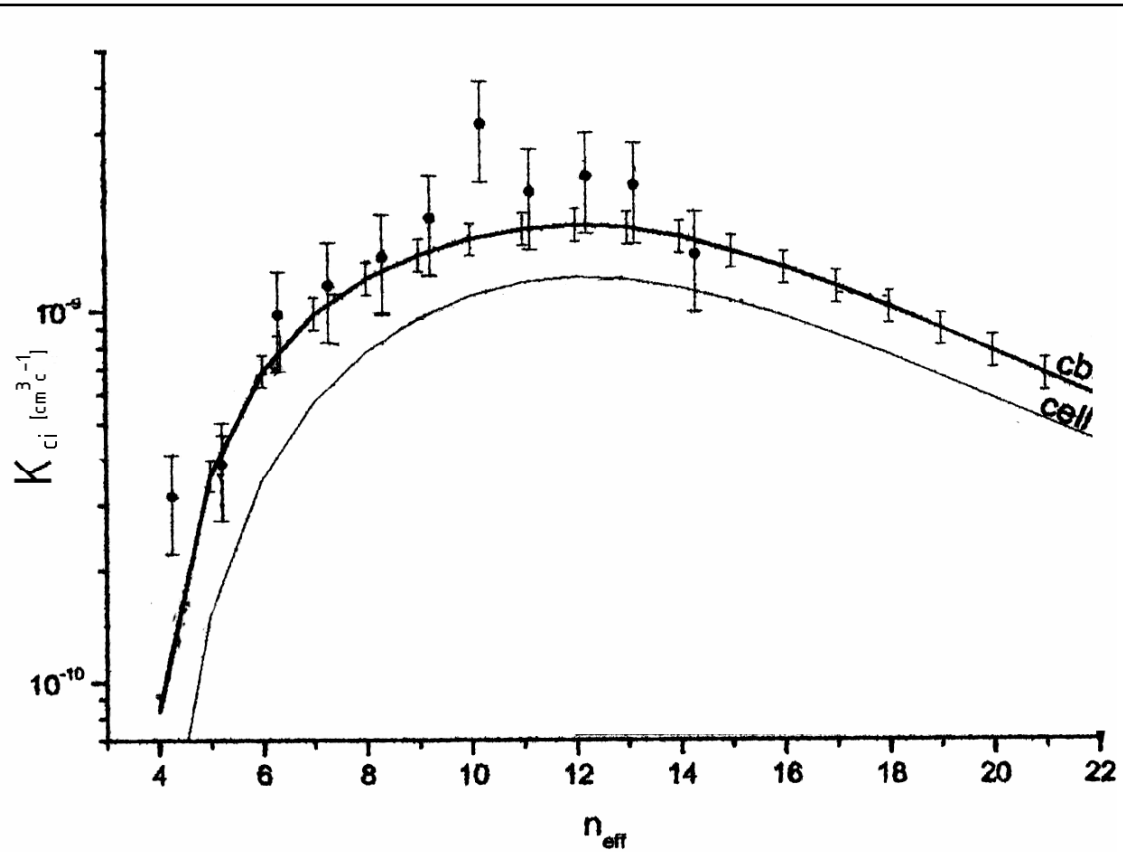


Chemi-ionization rate constants functions of the effective quantum number of excited states



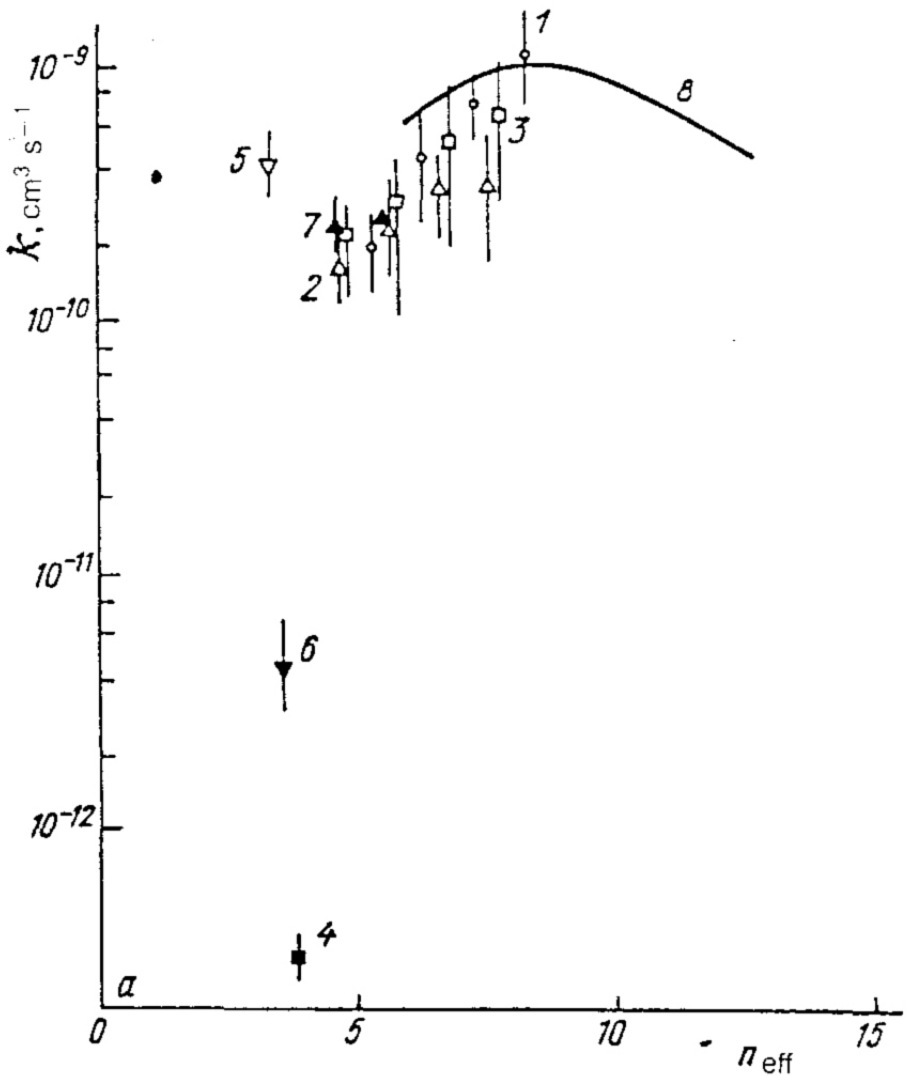
1—Li (1100 K), 2—Na (720 K), *3*—Na (600 K), *4*—K (660 K), 5—Cs (560K), *6*—range of values of *k* (Na*(L)+Na, L=0, 1 and 2, 1000 K),7—calculated using the model relying on electron capture to an autoionizing state of a negative ion (Na,500 K), *8*—qualitative form of *k(neff)* according to the model relying on the scattering of a quasi-free weakly-bound electron in the sodium atom; solid curve—DSMY model (Na, effusive beam, *700* K)

The coefficients for chemi-ionization in collisions $Na^*(n_{eff}\,^2P) + Na$



dotes: cb-conditions, (600K), associative ionization experiment
the full curve: cb (600K), cell (720K), theory

Chemi-ionization rate constant for as a function of the neff for Rb, Hg, and Cd



1 - Rb(n P)+Rb(5 S) (520 K)

2 - Rb(n D)+Rb(5 S) (470 K)

3 - Rb(n S)+Rb(5 S) (470 K)

4 - Rb(5 P) +Rb(5 P) (470 K)

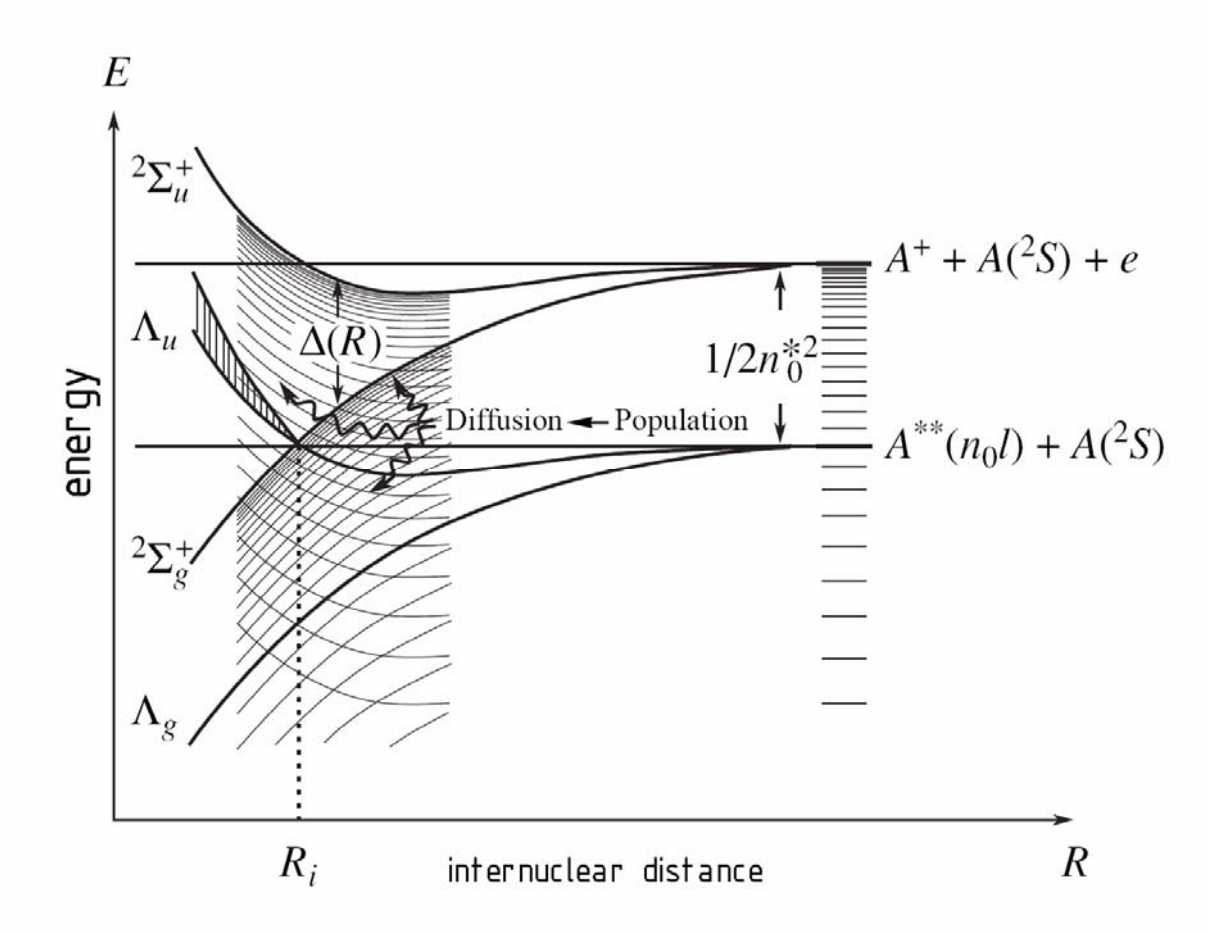
5 - Hg (300 K)

6 - Cd (575 K)

7 - Rb(D)+K(4 S) (440 K)

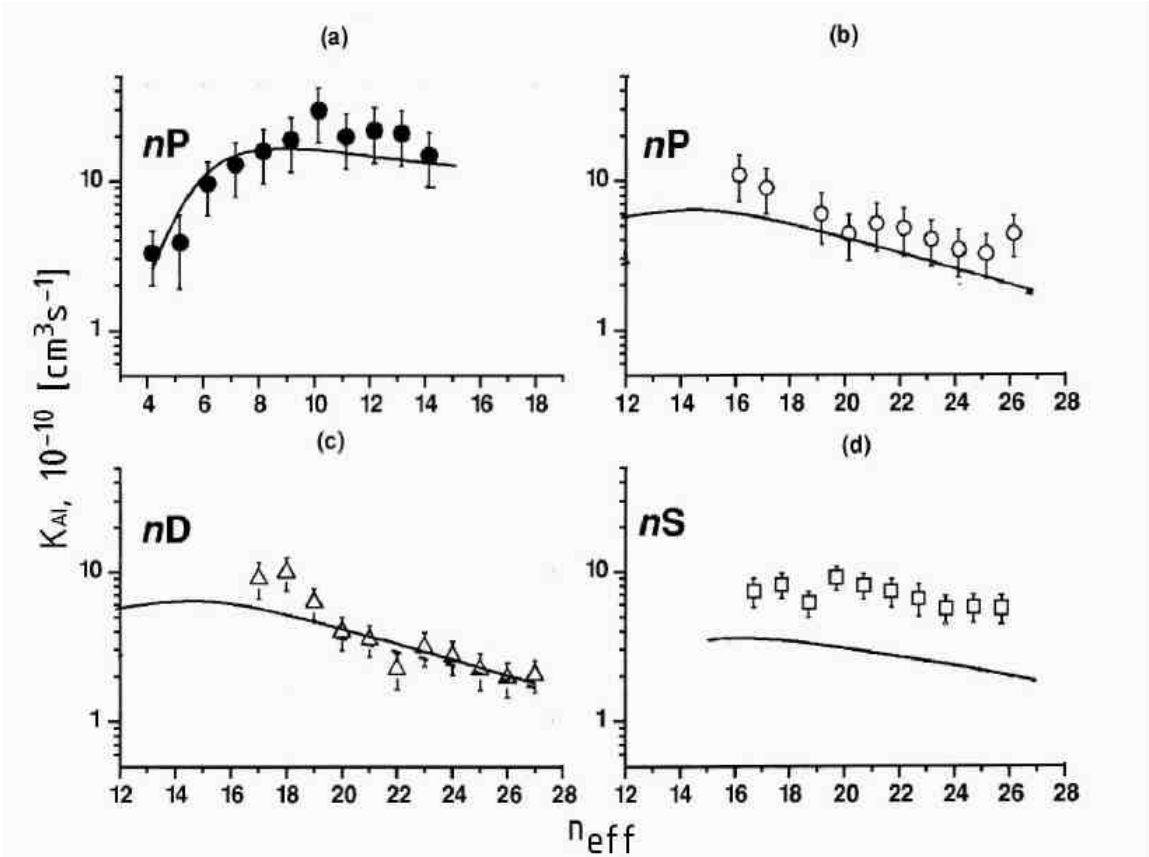
8 - DSMY model calculations for Rb (520 K)

Illustration of the mechanism of the RA + A collision process



Σ – the ionic states, Λ – the initial quasi-molecular states
Λ state crosses Σ state at Ri

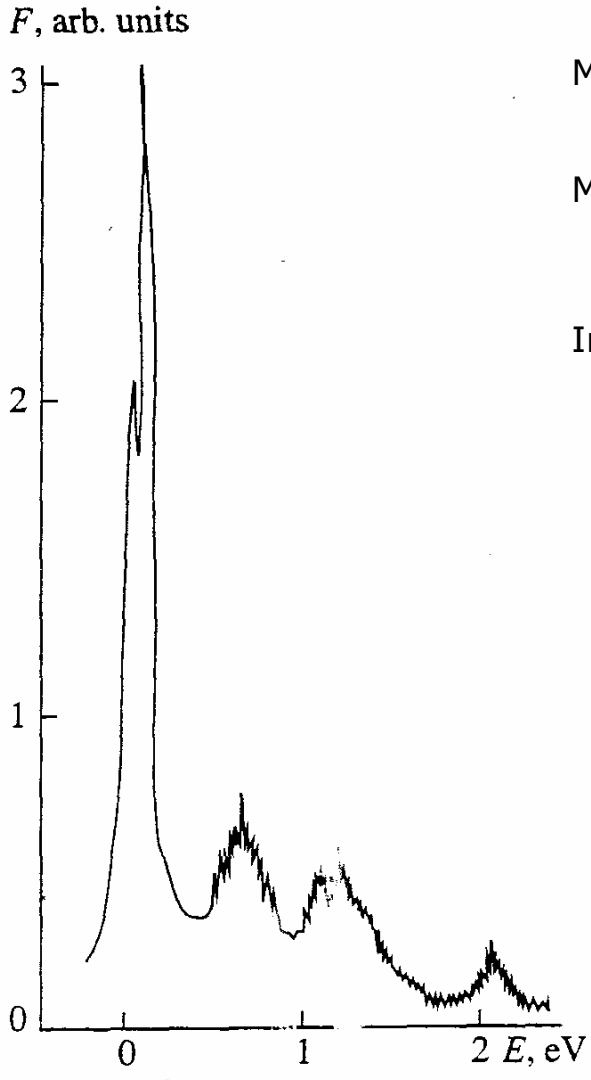
Experimental and stochastic theoretical *Na*(neff,l)* + *Na* AI rate coefficients



dotes - cb conditions, *l = 1 (600K);* open circle, sb-conditions, *l* = 1 (1000*K);* open triangle, sb-conditions, *l = 2 (*1000*K);* open square, sb-conditions, *l* = 0 (1000*K);*

full curves - theory, stochastic theory results

Energy spectrum of electrons with an energy from 0 to 2.1 eV formed during resonance Na vapor excitation

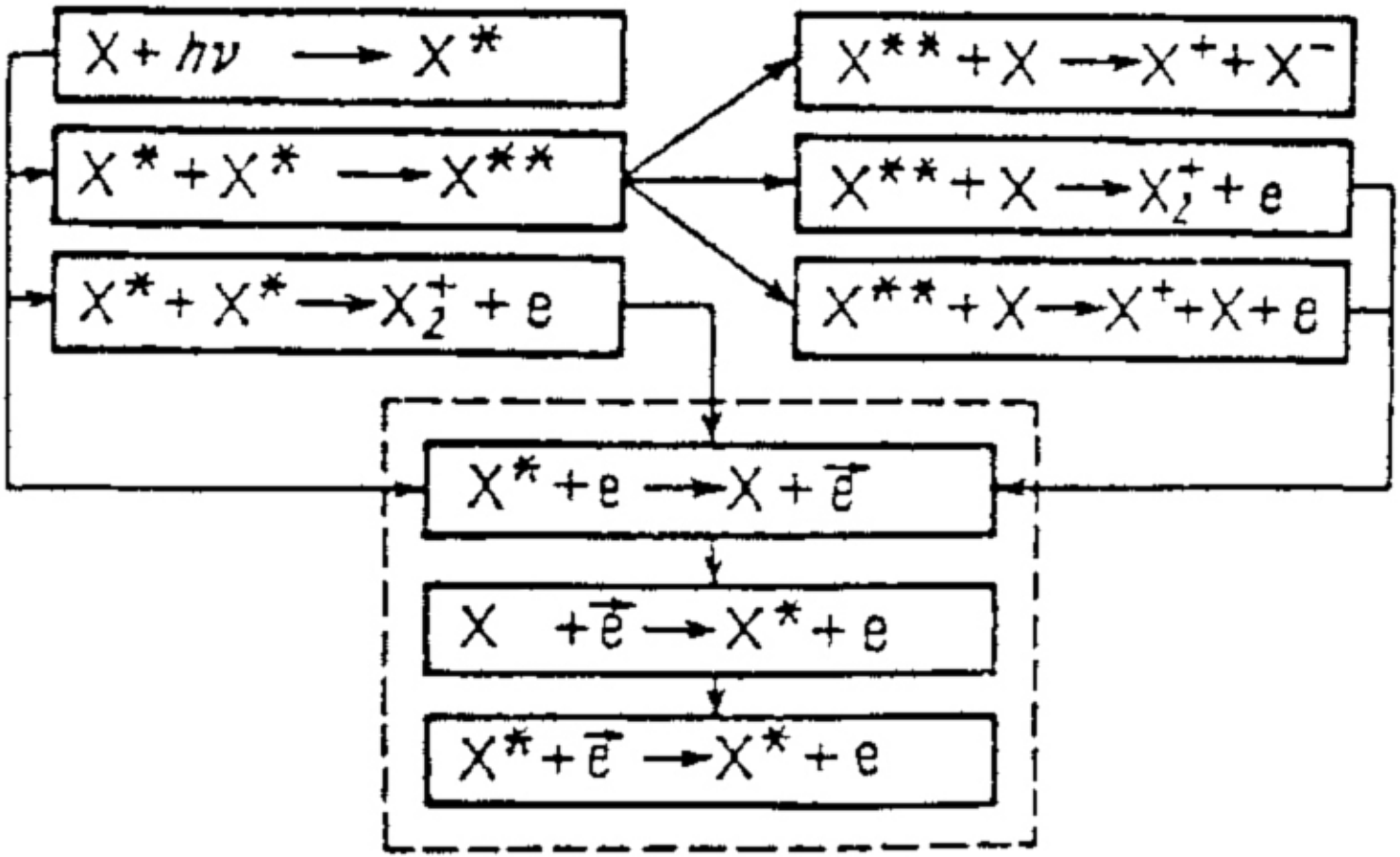


Main peak – primary electrons produced in AI

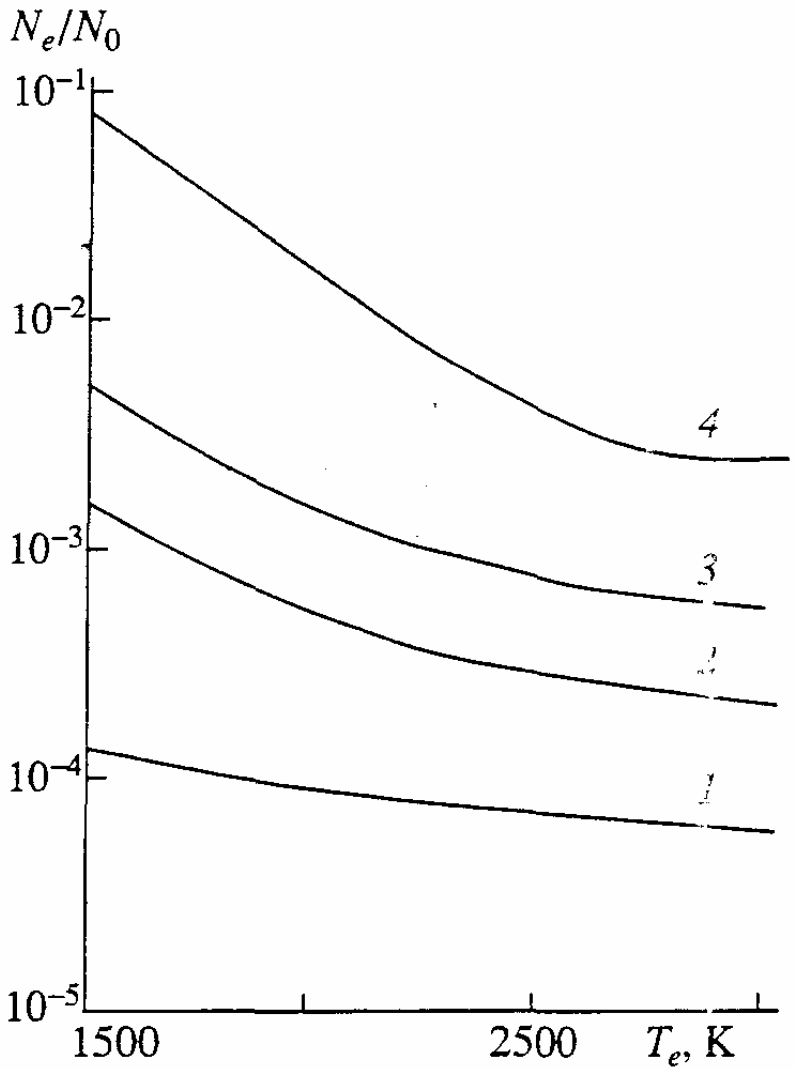
Maximum at E=2.1 eV is caused by collisions of the second kind

Intermedia maxima results from the photo- and collisional ionization RA via pooling processes

Illustration of possible mechanisms for the evolution of photo-plasma during absorption of resonant radiation



Concurrence between AI and radiative-collisional ionization in Cs plasmas



1 – Ta=500K,
Ne=10(14) cm(-3)

2 – Ta=1500K,
Ne=10(14) cm(-3)

3 – Ta=500K,
Ne=10(12) cm(-3)

4 – Ta=1500K,
Ne=10(12) cm(-3)

Conclusions

Presented results and preliminary model evaluations show that in the weakly ionized alkali plasmas, including astrophysical formations, specifically in volcanic gases on Io chemi-ionization processes can provide possible channels for primary medium ionization

Thank you for your attention!