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EXCHANGE COLLISIONS BETWEEN THE IONIC GROUND STATE AND THE NEUTRAL METASTABLE STATE OF ATOMS FORMED AND ALIGNED BY ELECTRON IMPACT

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# University of California Ernest O. Lawrence Radiation Laboratory

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Tetsuo Hadeishi and Chung-Heng Liu

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University of California  
Berkeley, California, U.S.A.

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The radio-frequency paramagnetic resonance method was used to observe the exchange collisions between the Xe ionic ground state having a  $2P_{3/2}$  configuration and the neutral metastable state having a  $3P_2$  configuration. The ionic ground-state and the metastable-state atoms are both formed and aligned by unidirectional-low energy, high flux electron beam impact. The magnetic resonance of the ionic ground-state atoms was observed by monitoring changes in the transparency of the resonance radiation to the metastable state.

By unidirectional-low energy electron impact excitation of Xe atoms from the  $1S_0$  ground state to the  $3P_2$  metastable state, the magnetic sublevels  $M_J = 0$  and  $\pm 1$  are more selectively excited than those with  $M_J = \pm 2$ . This is also experimentally verified from the paramagnetic resonance experiment of the metastable state. Similarly, certain magnetic sublevels of  $Xe^+(2P_{3/2})$  are expected to be selectively excited by the electron impact. Suppose if one would produce a high concentration of the aligned  $Xe^+(2P_{3/2})$  and  $Xe(3P_2)$  state atoms by high flux electron beam, a certain population equilibrium will be reached in a steady state. A destruction of the alignment of  $Xe^+(2P_{3/2})$  would result in a new population re-distribution of the  $Xe(3P_2)$  metastable state. Such a phenomenon is observable by monitoring

the change of transparency of linearly polarized resonance radiation due to the absorption of the light by the metastable state.

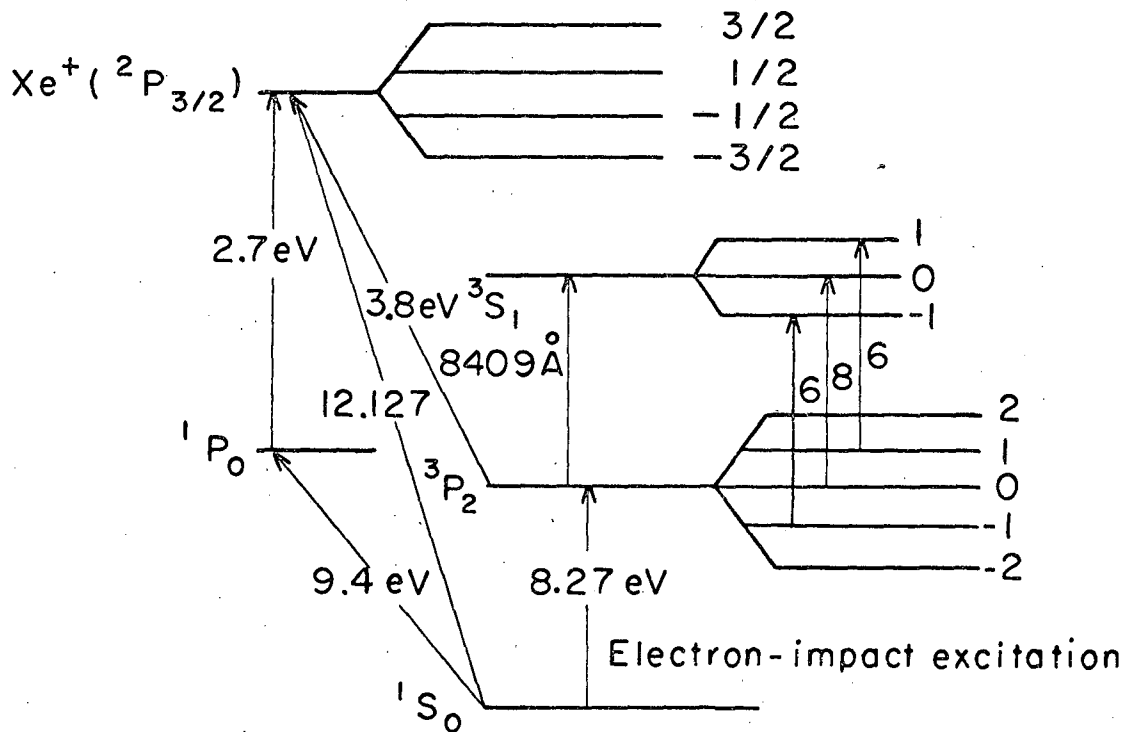
The high flux, low energy-unidirectional electron beam was obtained by means of space charge neutralized electron flow using a planar diode structure electron tube with an indirectly heated "hot" cathode operating under the Xe gas pressure of about  $5 \times 10^{-4}$  torr at  $70 \text{ mA/cm}^2$  electron current density at slightly above the ionization potential of Xe. The first slide shows the relevant energy level diagram. The second slide shows the experimental arrangement.

The third slide shows an experimental result which gives the  $^3P_2$  as well as  $^2P_{3/2}$  magnetic resonances. The fourth slide shows the magnetic resonances of  $\text{Xe}^{129}(^3P_2)$ ,  $\text{Xe}^{131}(^3P_2)$ , and even isotope  $\text{Xe}^+(^2P_{3/2})$ .

Recently we observed that the nucleus of  $\text{Xe}^{131}$  having  $I = 3/2$  can also be aligned by metastability exchange between an initially randomly oriented nucleus in the  $^1S_0$  ground state and aligned  $\text{Xe}^{131}(^3P_2)$  by electron impact. The fifth slide shows the experimental result of nuclear alignment by metastability exchange collisions.

Thus by means of an extremely simple apparatus, we have found that:

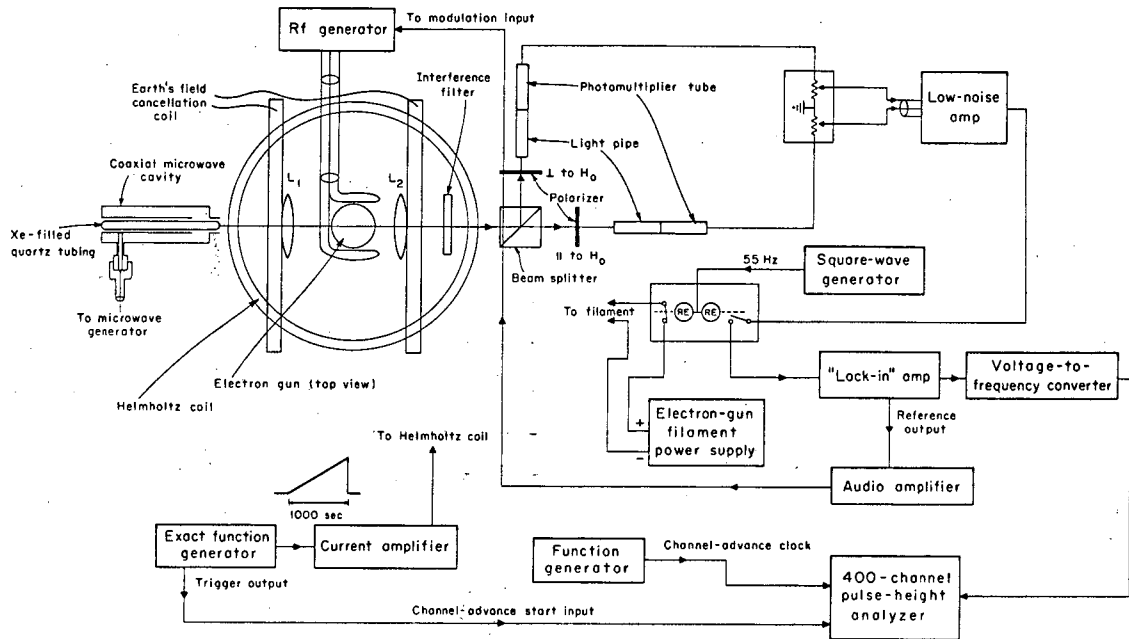
(1) it is possible to observe alignment of the ionic ground state and (2) it is possible to align the nucleus in the  $^1S_0$  ground state. A more detailed investigation is presently in progress to study the mechanisms involved more precisely.



Relevant energy level used in  $Xe(^3P_2)$  resonance absorption

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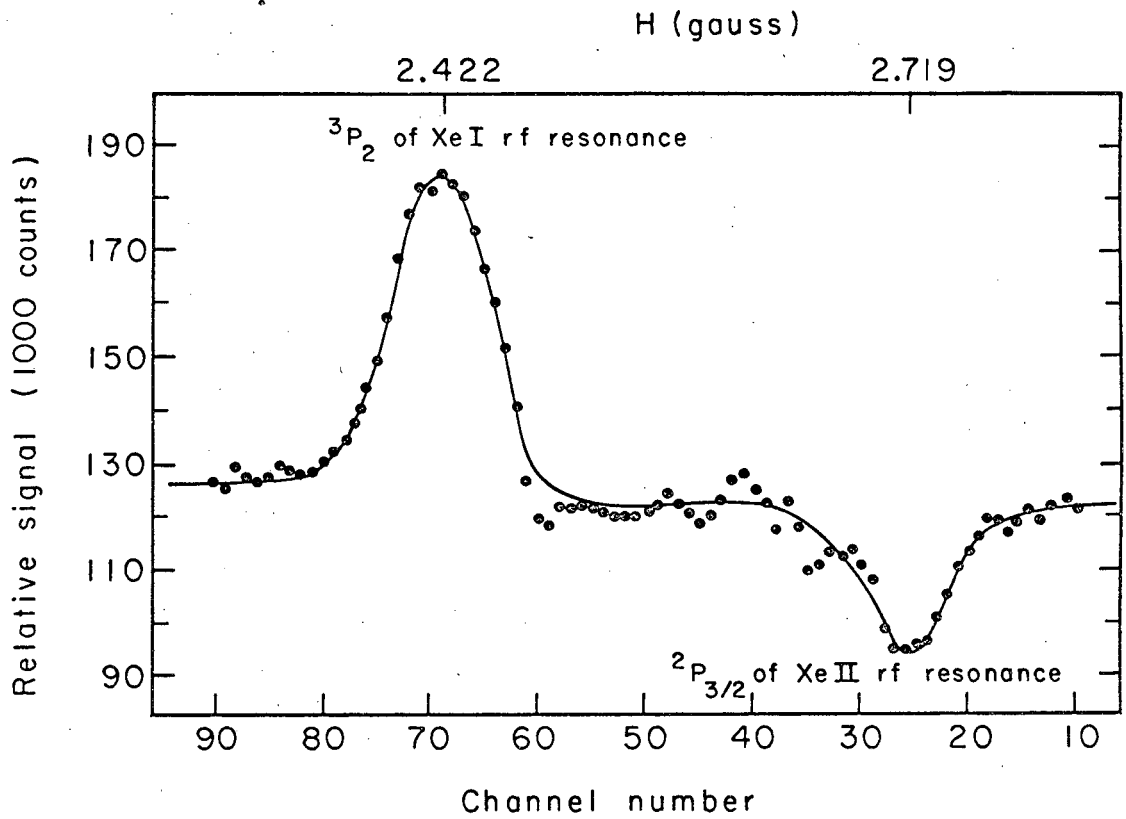
Slide 1.



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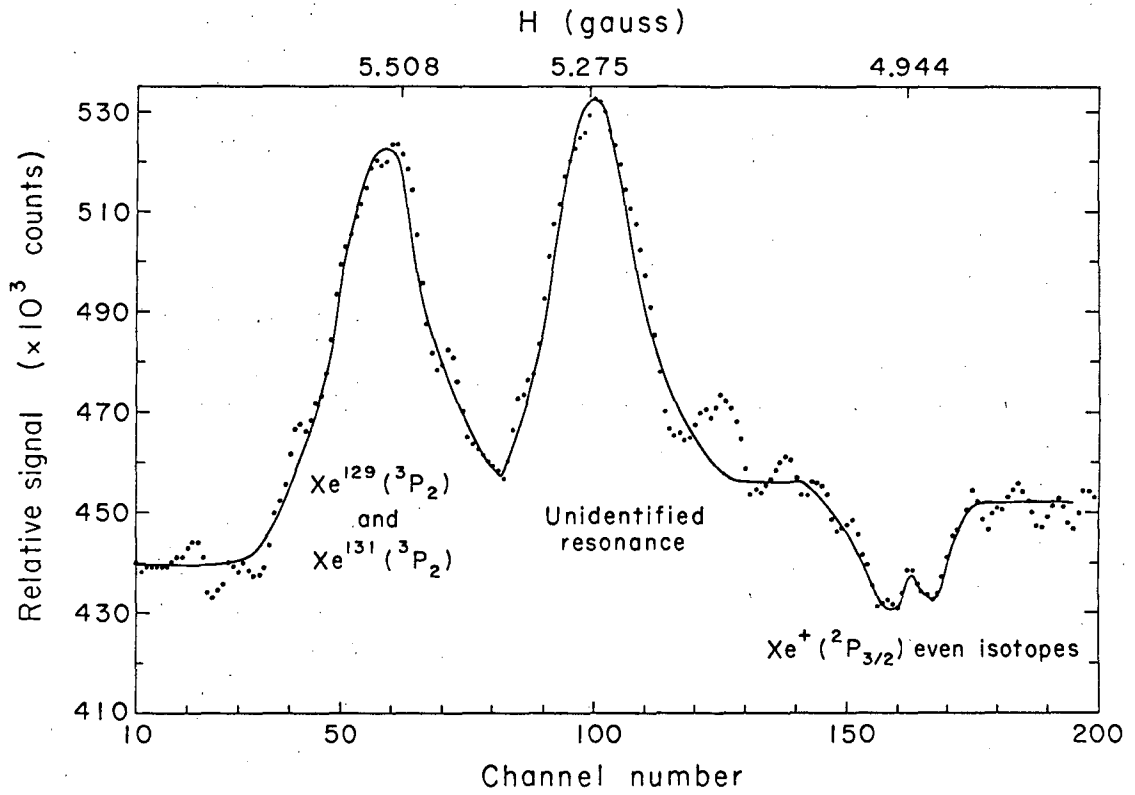
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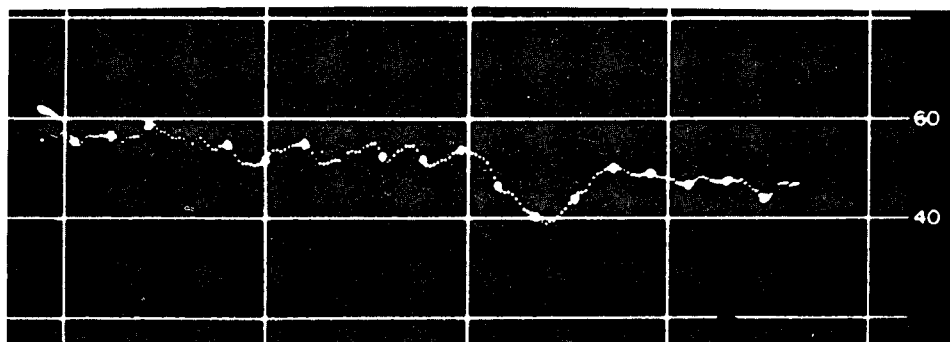
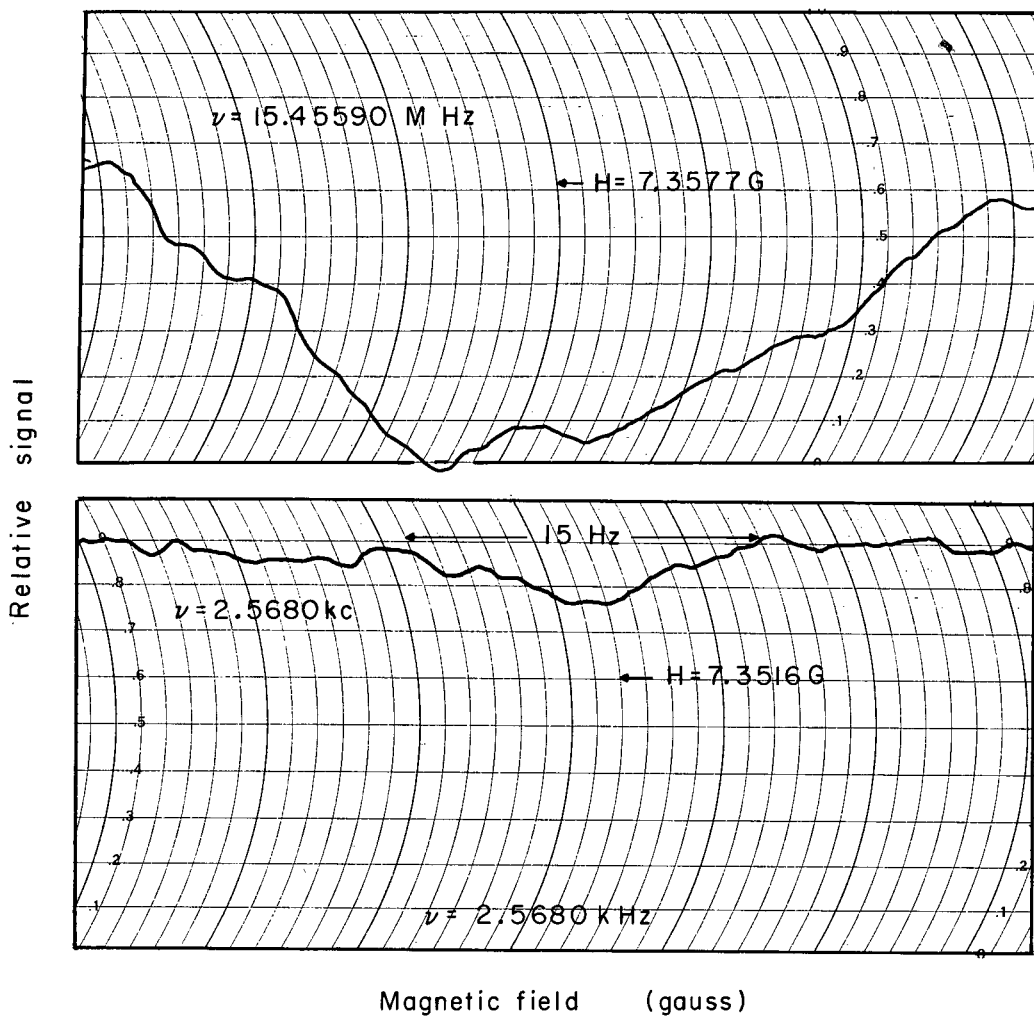
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Slide 3.



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Slide 4.



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