Xe_2 Excimer IR Fluorescence in Gaseous Mixtures

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OUTLINE

- Introduction
- Experimental Technique and Apparatus
- Results and Rationalization
- Conclusions

Introduction

- Knowledge of V_0 at high density;
- Direct measurements of V_0
  - Work function (electrodes contamination)
  - Synchroton radiation absorption by impurities (CH_3Br, CH_3I) in buffer gases (no low energy, accuracy);
  - Laser absorption by Rydberg states (only low pressure);
- Indirect determination from mobility data.

Present Technique

- Spectroscopic technique
- Electron impact excitation of Xe gas at high pressure (broadband, low cost) with Xe_2 excimer formation
- Optically active electron loosely bound (low energy, high resolution)

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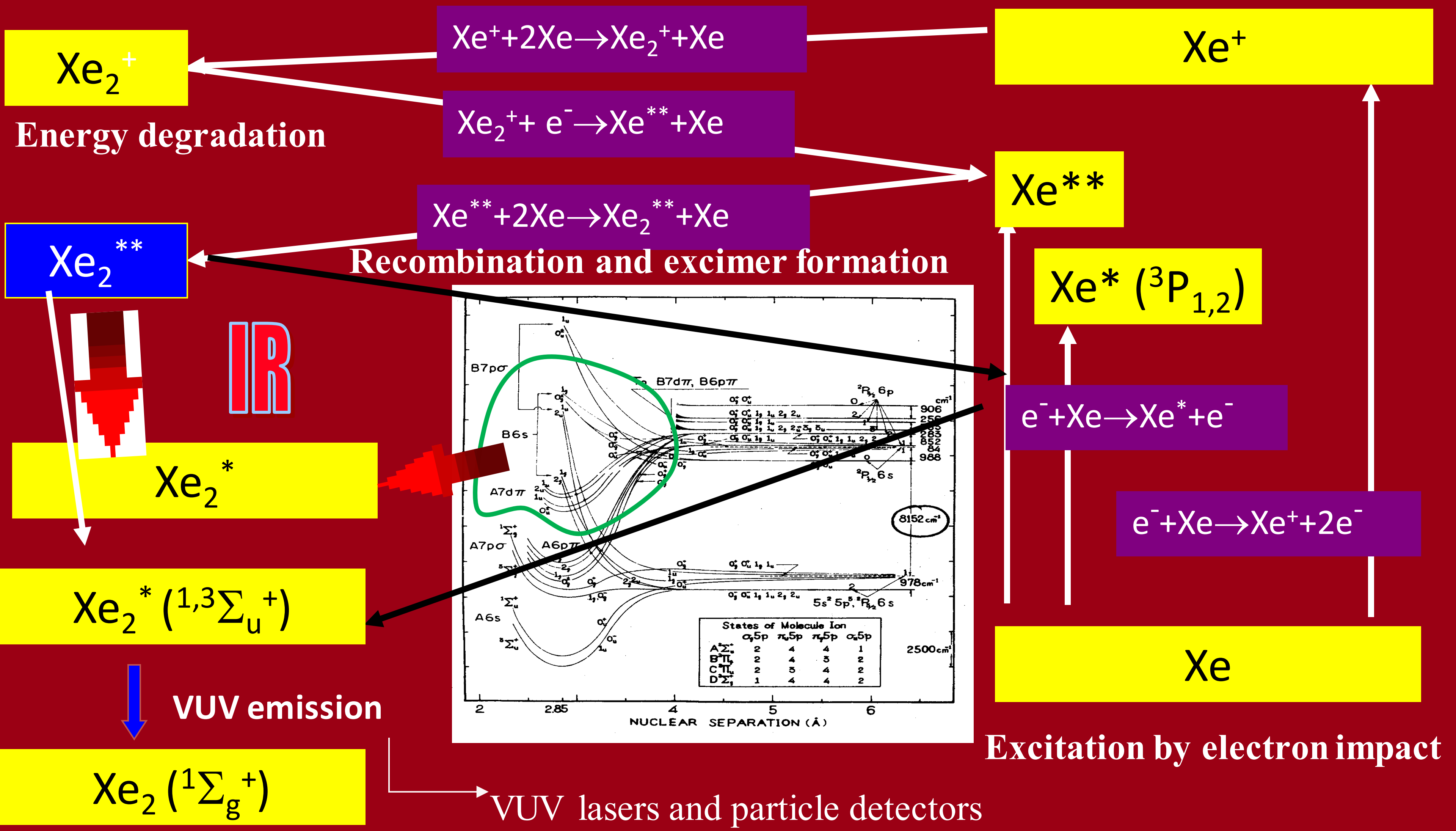
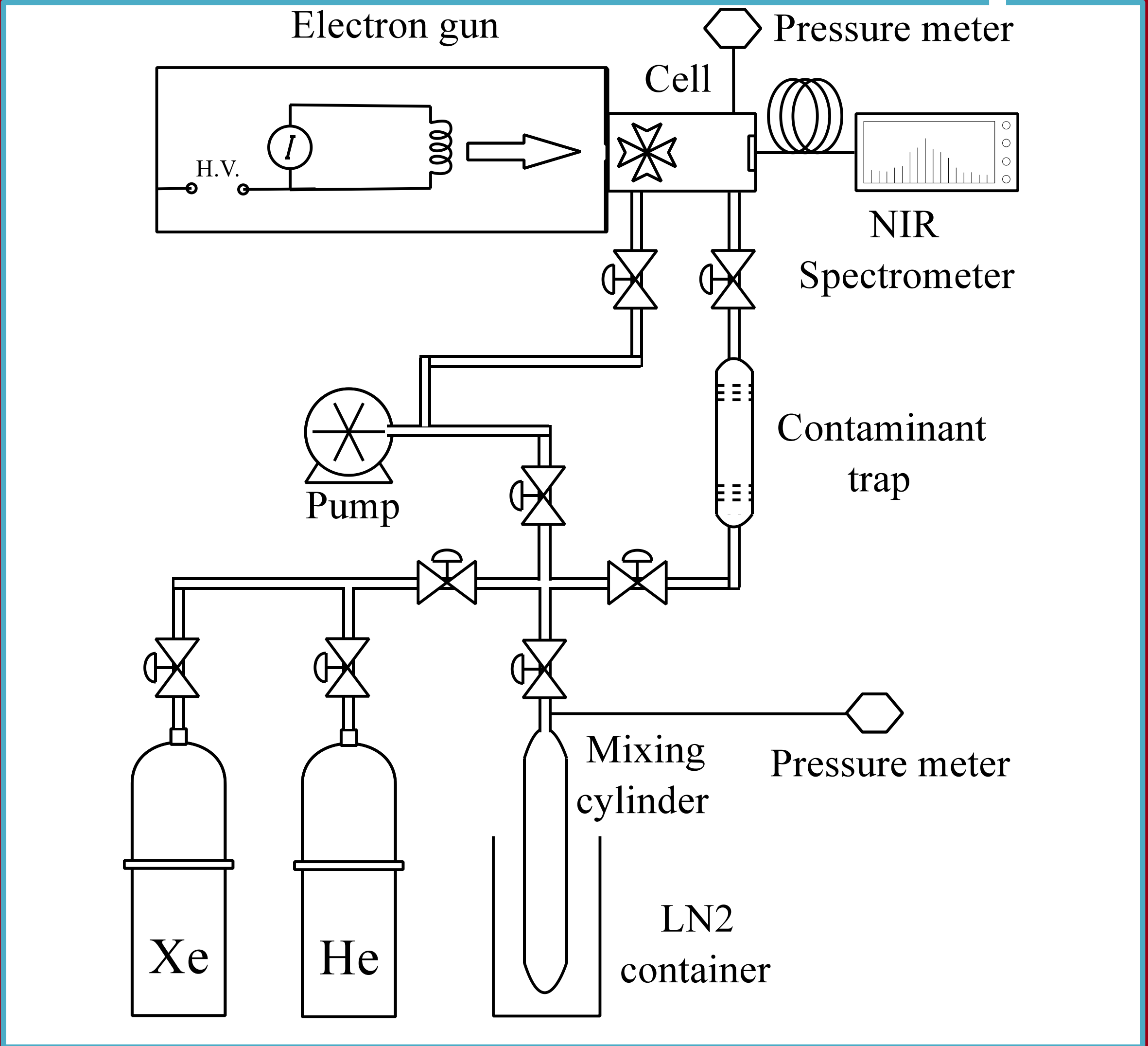
Excimer fluorescence

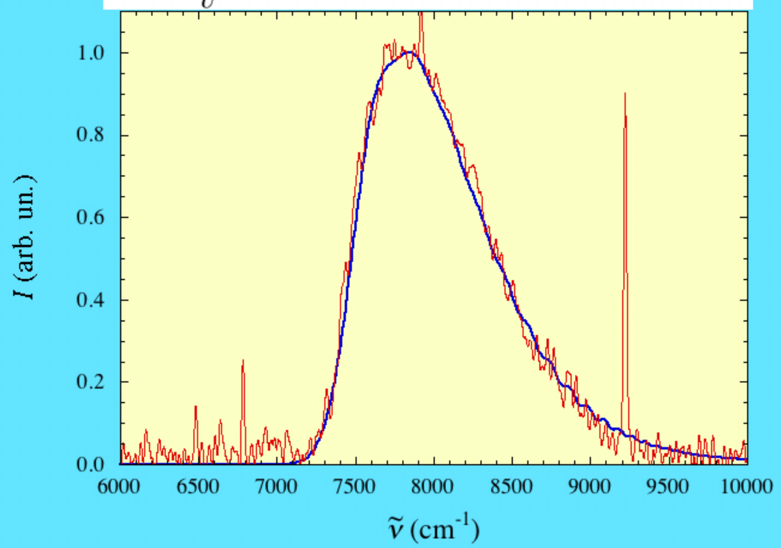


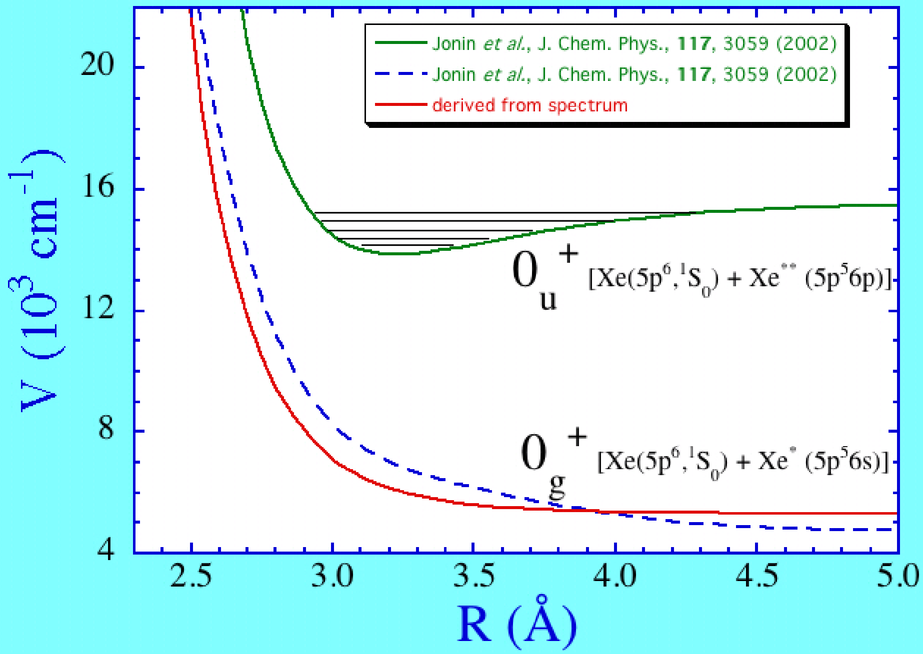
Present Technique



Xe_2 levels for IR emission

$$I \propto \sum_{v'} e^{-\beta E_{v'}} \left[E_{v'} - \epsilon''\right]^4 \left|\langle v' | \epsilon'' \rangle\right|^2$$





Low pressure *P*=0.01 MPa

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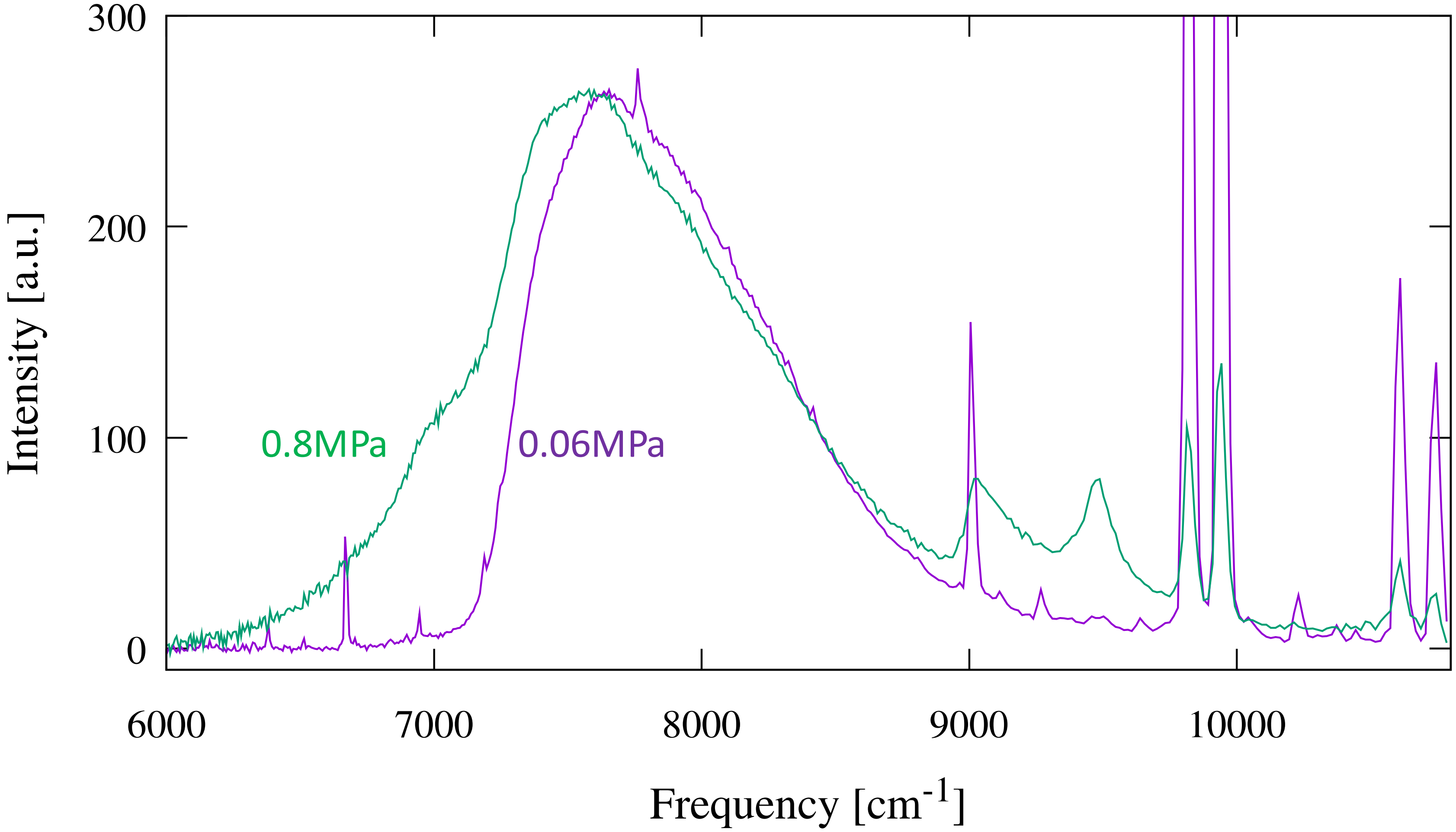
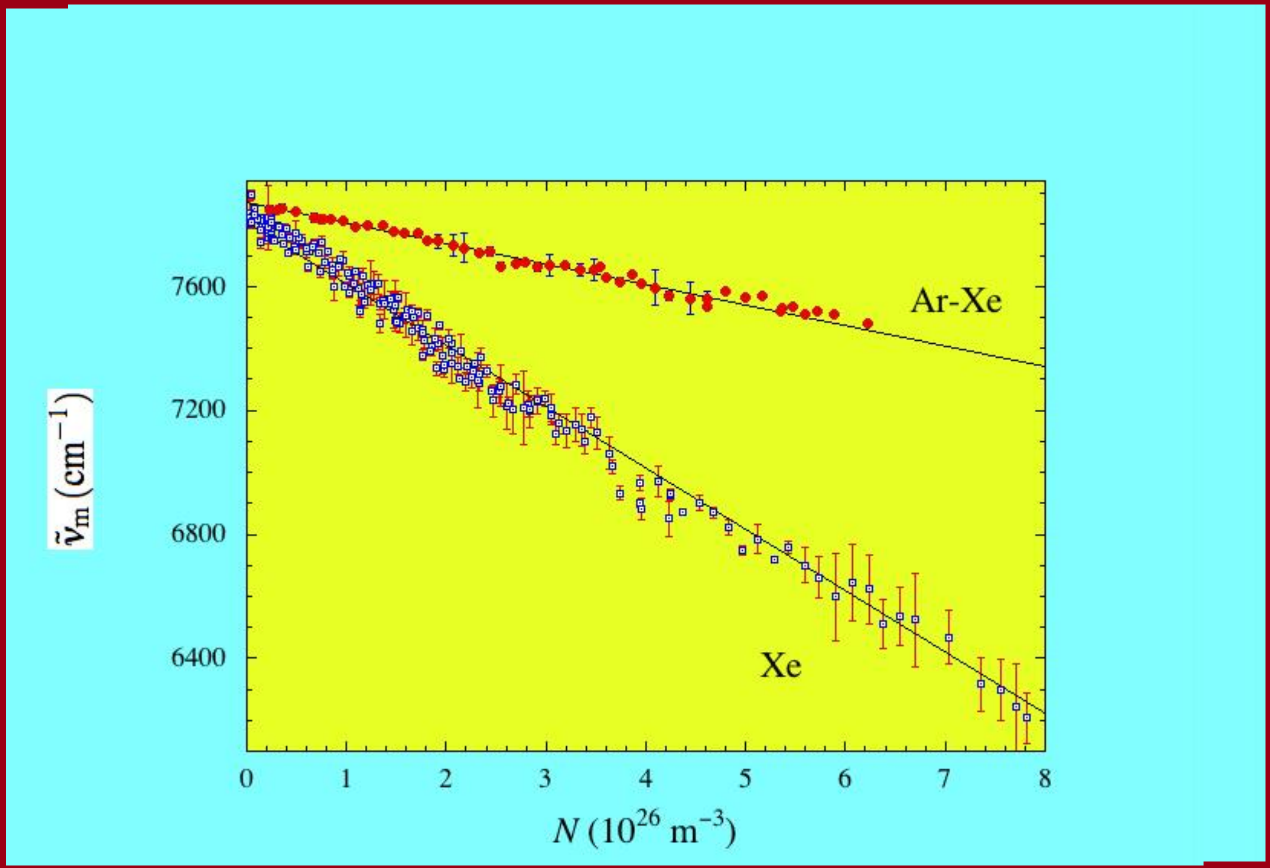
Experimental Results (pure Xe)



Experimental Results

$$hc\tilde{\nu}_m = \frac{\langle V_{0_u^+} - V_{0_g^+} \rangle}{K^2(N)} + V_0(N)$$

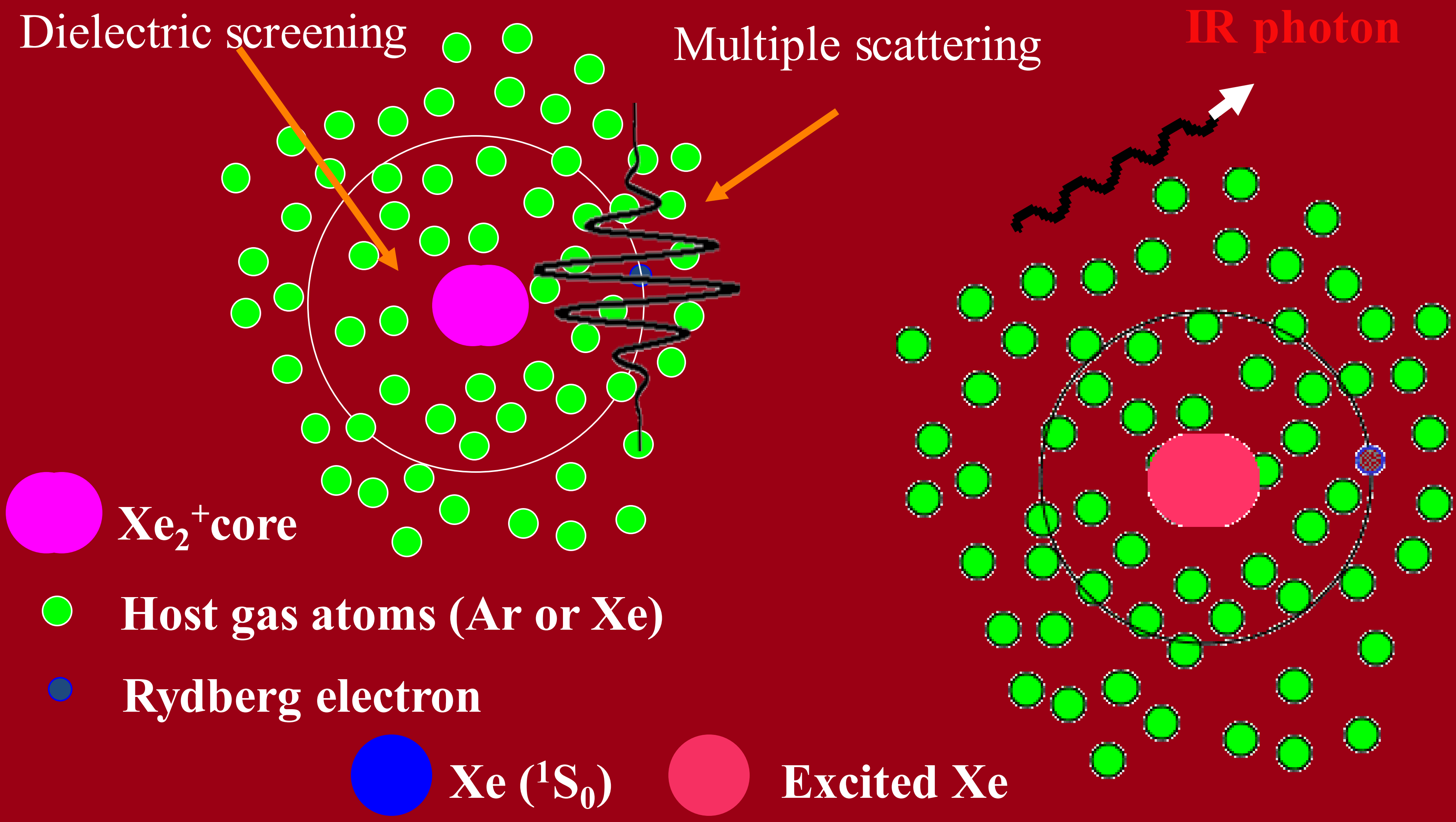
$$\tilde{\nu}_m = \tilde{\nu}_{m0} - \left(\tilde{\nu}_{m0} \frac{2\alpha}{\epsilon_0} - \frac{h}{mc} a \right) N$$



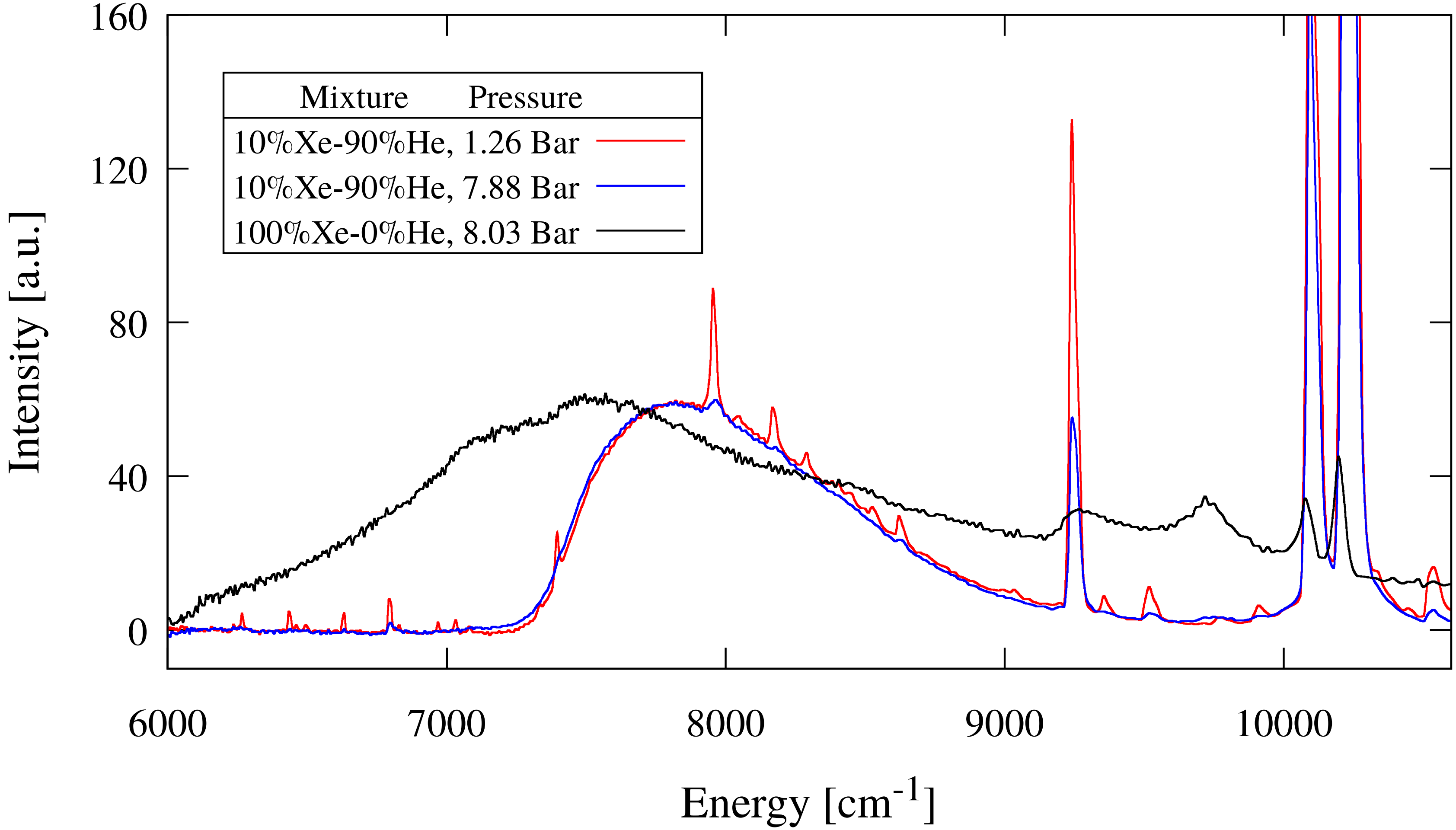
1. **The excimer is assumed to be obtained by adding a Rydberg electron to a valence state of a Xe_2^+ ion (Mulliken 1970);**
2. **it interacts with the atoms of the gaseous environment;**
3. **the energy levels of the excimer are affected by two density-dependent effects: one classical and one quantum**

1. **SOLVATION EFFECT**: many atoms of the host gas are encompassed within the large orbit of the Rydberg electron and screen the Coulombic interaction between the electron and the ion core
2. **MULTIPLE SCATTERING EFFECTS**: the Rydberg electron is so largely delocalized that its wave function spans over many atoms of the host gas yielding a shift $V_0(N)$ of its energy, as predicted by Fermi (1934)

Naive Picture

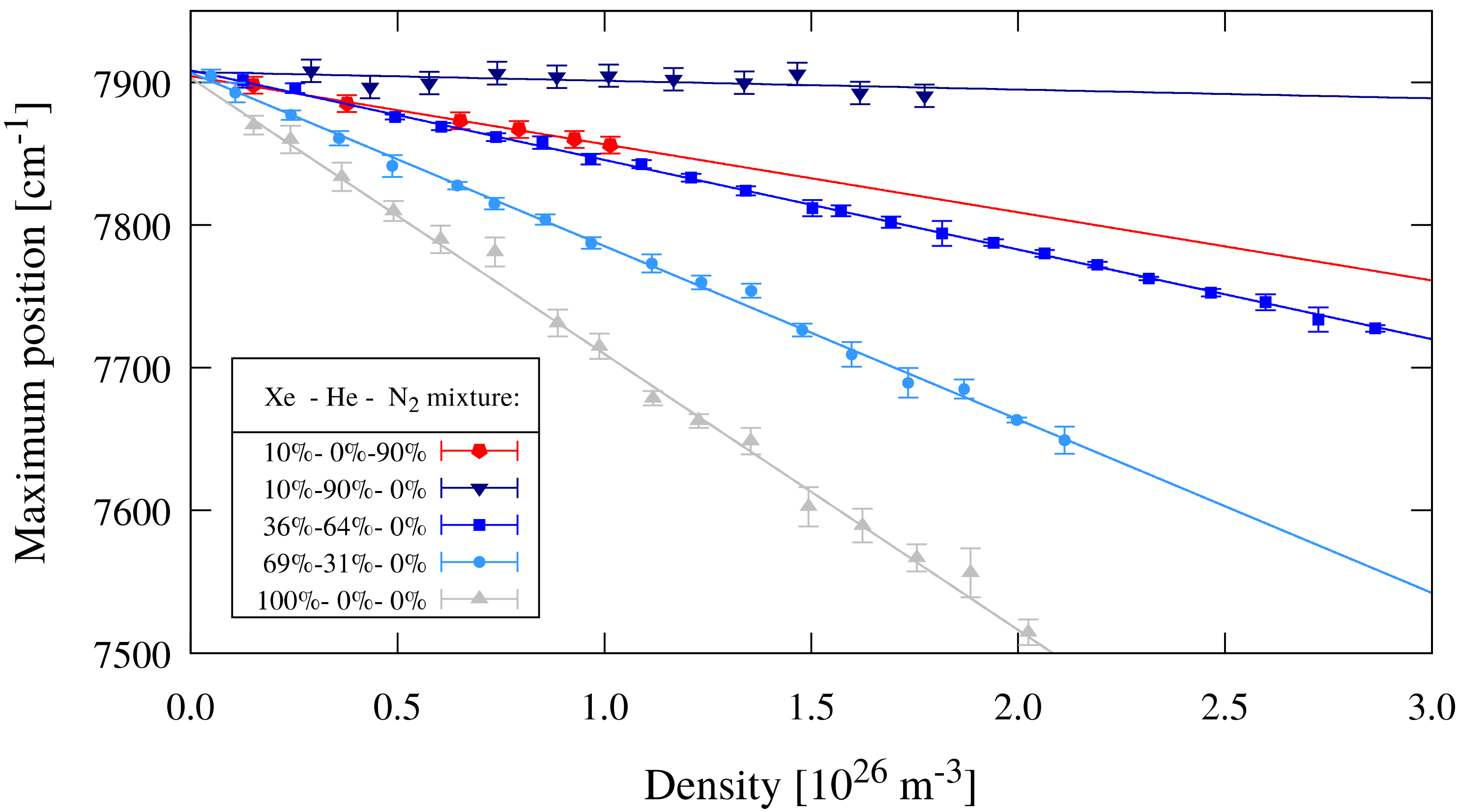


Exp. Results (Mixtures)



Exp. Results (Mixtures)

$$\tilde{\nu}_m = \tilde{\nu}_{m0} - \left\{ \frac{2\tilde{\nu}_{m0}}{\epsilon_0}(x\alpha_1 + (1-x)\alpha_2) - \frac{h}{mc}(xa_1 + (1-x)a_2) \right\} N$$



Exp. Results (Mixtures)

Table 1: Slope Values

	Experimental $10^{-24}\,\mathrm{m}^2$	**Theoretical** $10^{-24}\,\mathrm{m}^2$
Xe (10%) - N_2 (90%)	-47.7 ± 1.1	-43.2 ± 3.0
Xe (11%) - He (89%)	-6.1 ± 3.3	-4.0 ± 2.1
Xe (36%) - He (64%)	-60.2 ± 0.7	-58.1 ± 1.2
Xe (69%) - He (31%)	-122.4 ± 1.3	-130.5 ± 4.7
Xe (100%)	-193.4 ± 3.3	-198.8 ± 1.7

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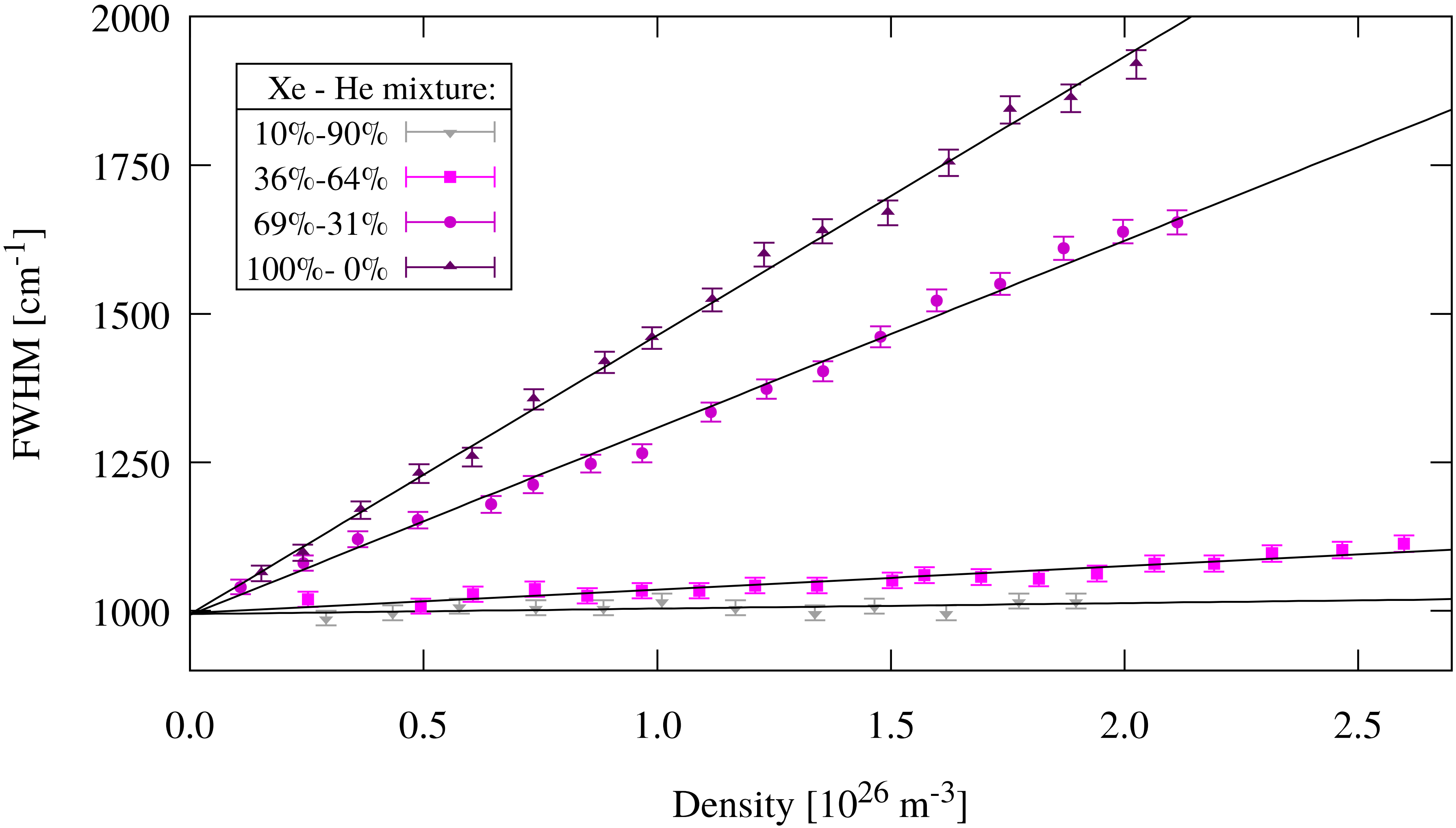
Exp. Results (what ?)



CONCLUSIONS

- The experiment in mixtures validates the model;
- For gases whose α and *a* are well known this techique allows a direct measure of V_0;
- For gases, whose *a* is known with large uncertainty, this technique may be an alternative for its direct determination.

Thanks for the attention!