Experimental measurement of the van der Waals binding energy in $Xe_n - O_2$ complexes with velocity map imaging technique

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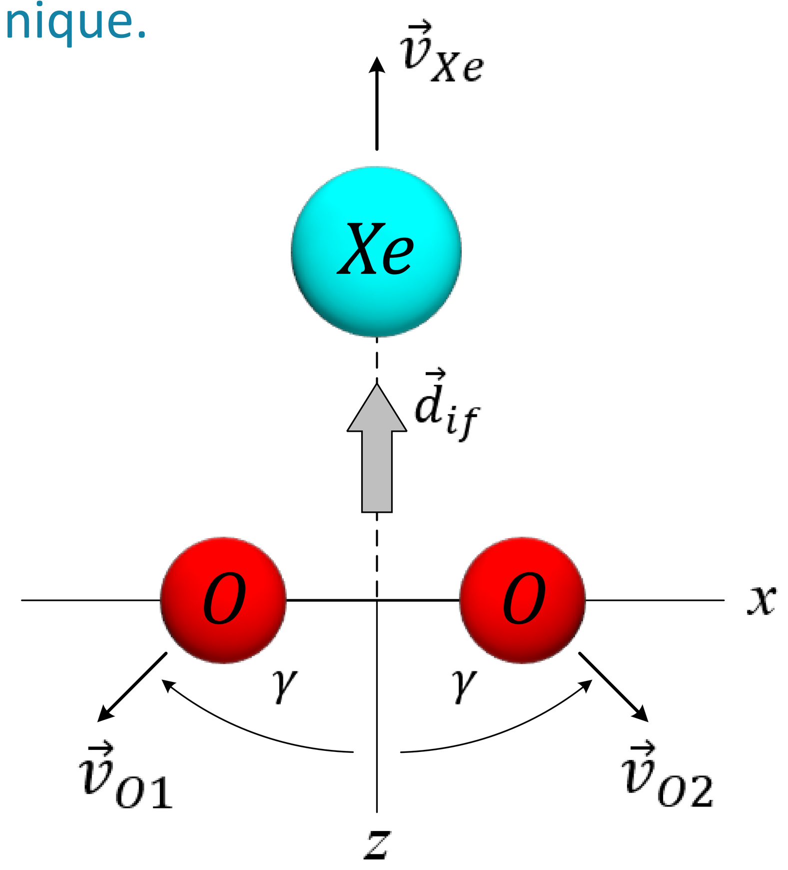
Introduction

Interest to the van der Waals complexes of xenon with oxygen is provided by the known application of xenon as an anesthetic agent. This effect is very surprising because xenon is inert gas. The mechanism of this anesthetic action is still not known. There is an assumption that the complexes of xenon with oxygen can play an essential role in this anesthetic effect. This dictates interest to the binding energy and structure of van der Waals complexes of oxygen with xenon. In the current work the measurements of the binding energy are carried out with the approach based on the use of velocity map imaging of the photofragments arising in photodissociation of van der Waals complexes.

Methods

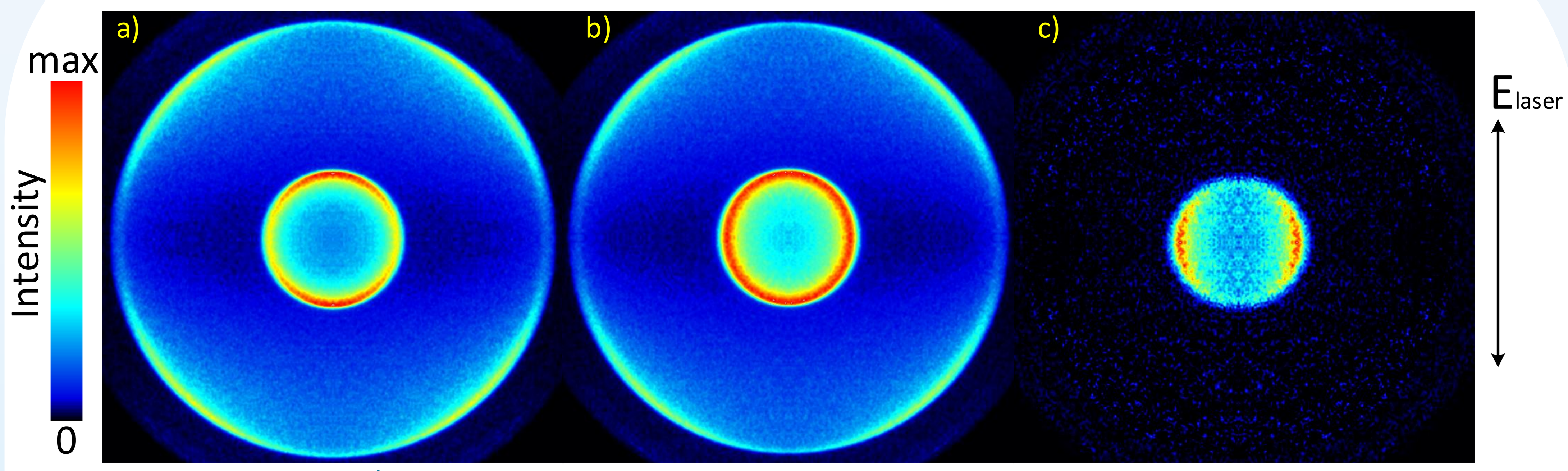
In these experiments the van der Waals oxygen-xenon complexes are generated in a cold supersonic molecular beam. UV-laser radiation used for excitation of complexes is also used for resonance-enhanced photoionization O atoms arising in the photodissociation of O_2 in complexes. The distribution of O^+ photoions over kinetic energy and the angular anisotropy of their recoil were measured using velocity map imaging technique.

The comparison of the kinetic energy and angular distribution of O atoms formed from an oxygen-xenon complex with those observed for the photodissociation of non-bonded oxygen molecule allows us to extract the binding energy of the complex $Xe - O_2$.

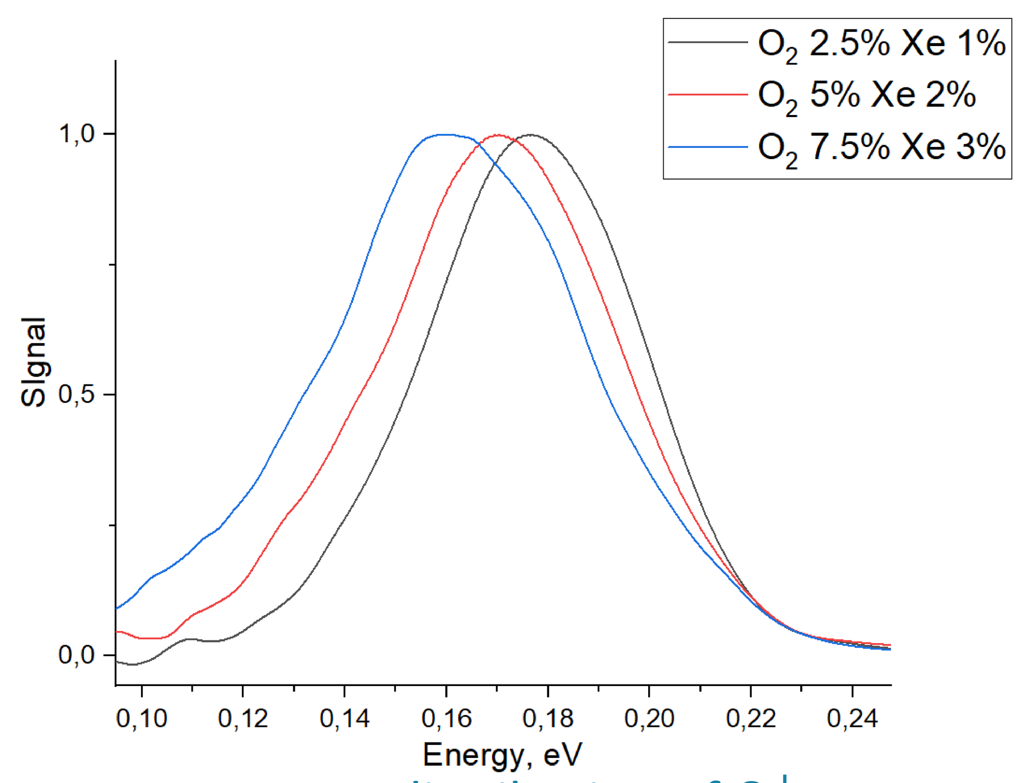


Anisotropy parameter: $\beta = (3\cos^2\gamma - 1)$

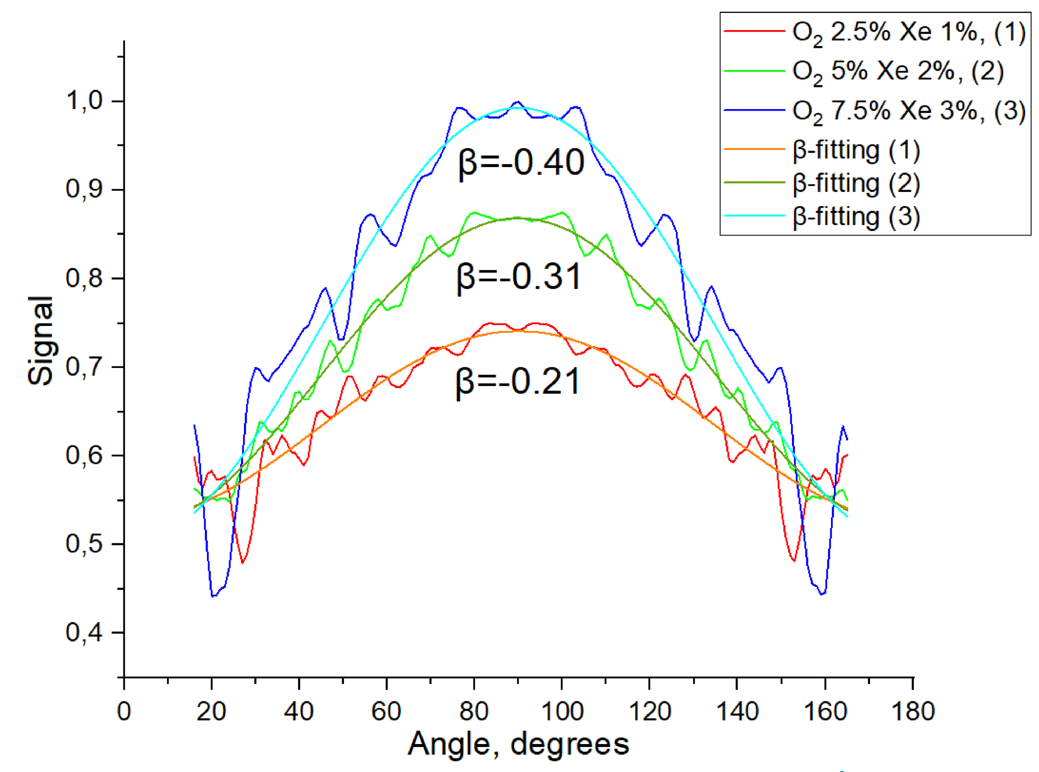
Results



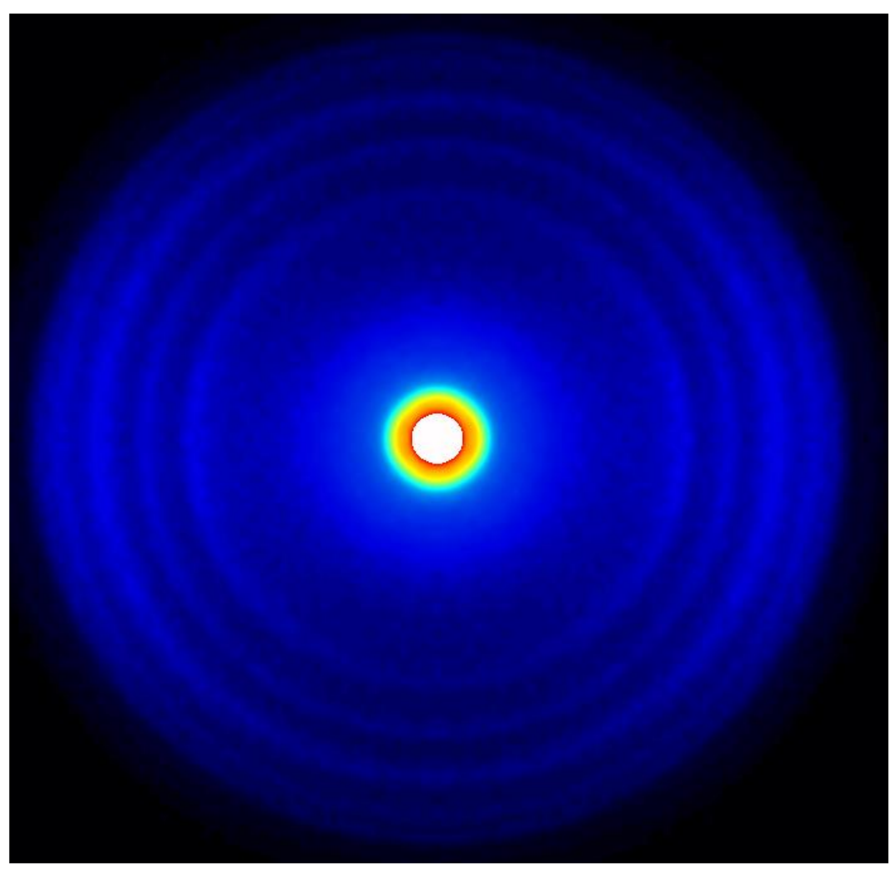
Velocity maps of O^+ formed from photodissociation of particles in mixtures of Helium and a) pure O_2, b) O_2 and Xenon; c) contribution of $Xe - O_2$ complexes (subtracted signal b)-a))



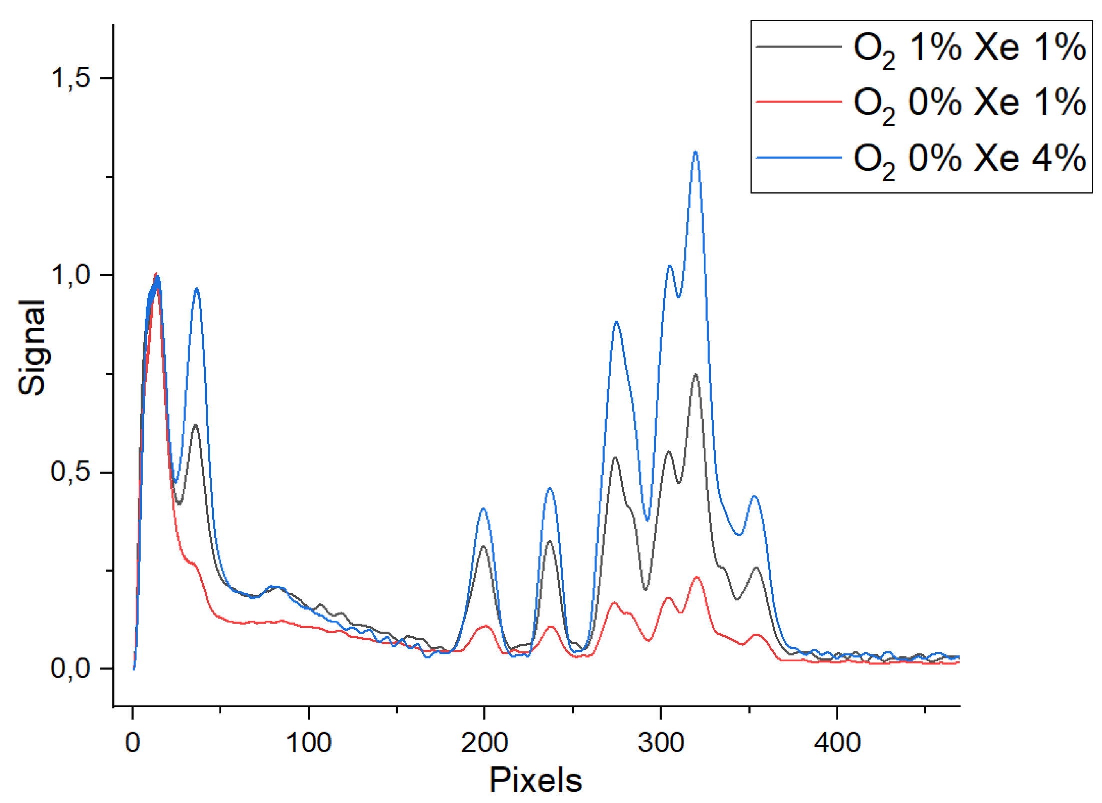
Energy distribution of O^+



Angular distribution of O^+

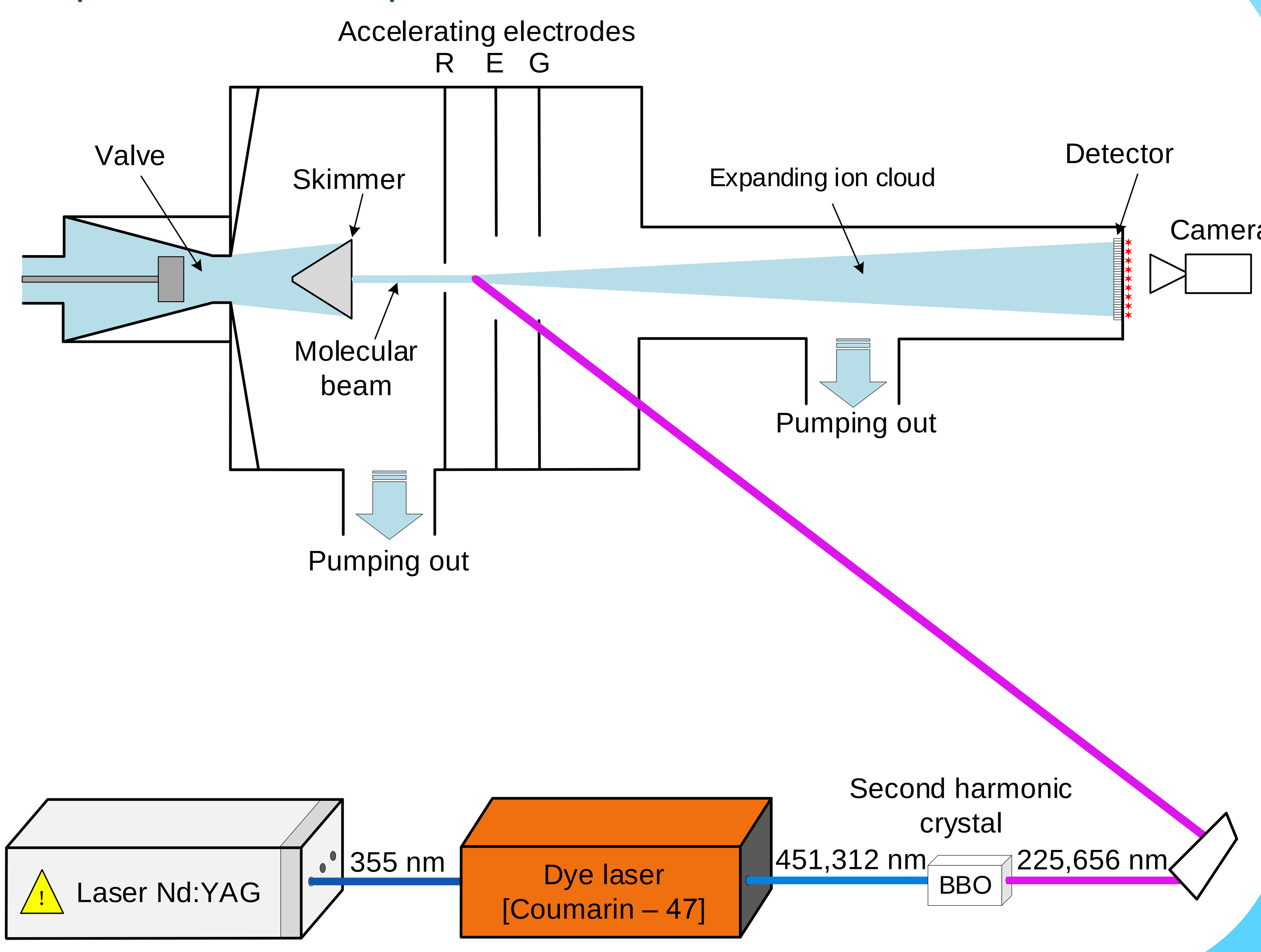


Velocity map of Xe^+



Velocity distributions of Xe^+

Experimental setup



Energy of $Xe - O_2$ complex

$$D_{vdW}(Xe - O_2) = 2T_O - 2T_1\left(1 + \left(\frac{2}{3}(\beta + 1)\frac{m_O}{m_{Xe}}\right)\right)$$

T_O, T_1 -kinetic energy of O^+ formed from photodissociation of O_2 and $Xe - O_2$ respectively, β – anisotropy parameter

Conclusion

As a result of the work, velocity maps for mixtures with different concentrations of Xe and O_2 were measured. The velocity maps were used for extracting angular and energy distributions of the O^+ signal from photodissociation of $Xe - O_2$ complex. It allows us to estimate the van der Waals binding energy in the complex to be 150-180 cm^{-1}.

Experimental evidence of the formation of more complicated complexes of xenon with oxygen complexes $Xe_n - O_2$ was also obtained. It was observed that the shift in kinetic energy of atoms increases with xenon concentration in the expanded gas mixture. Also, the velocity maps of xenon atoms were measured. The results indicate the formation of xenon clusters Xe_n and complexes of these clusters with oxygen molecule $Xe_n - O_2$.