3P067

Momentum Imaging Spectroscopy of Rare Gases and Fullerenes by using Synchrotron Radiation

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A time-of-flight (TOF) based momentum imaging spectrometer has been developed to observe the momentum distributions of the scattered fragments produced from dissociative photoionization of gaseous $\mathbf{C_{60}}$. We have adopted the Eppink-Parker type three element velocity focusing lens system[1] (Repeller, Extractor, and Tube electrodes) to achieve the high kinetic energy (KE) resolution on the photofragment images. We have already designed the momentum imaging apparatus[2] which has been installed in the end station at the BL2B of the UVSOR facility[3, 4]. Recently, we have completed the performance check of this spectrometer by using five rare gases (He, Ne, Ar, Kr, and Xe) at 300 K in the photon energy of $h\nu = 35$ eV.

In a momentum imaging spectrometer, the original 3D scattering distributions of the photofragment ions are projected onto a 2D position sensitive detector (PSD) as a real image. One can convert from the projected image to the initial 3D velocity distributions by using the inverse Abel transformation[5], if there is an axis of cylindrical symmetry parallel to the image plane. After this transformation, we can obtain a cross-sectional image of the 3D velocity distribution on the x – y plane. Here, x and y denote the central (symmetrical) axes of the molecular and photon beams, respectively. The distance from the origin of the cross-sectional image is directly proportional to the speed. From the radial distribution of the image we can calculate the speed distribution by using the conversion factor, $V = P_N / T$, where V, P_N, and T are the velocity, pixel number, and calculated TOF of ion, respectively.

Fig. 1. shows the extractor-voltage dependence of the projected image of Kr at 300 K. These images were measured by applying the different extractor voltages with keeping the repeller and the tube voltages at 450 V and −350 V, respectively. The panels **(a)** – **(e)** correspond to the extractor voltages of 200, 205, 210, 215, and 220 V, respectively. We converted images **(a)** – **(e)** to the y-projections (the one-dimensional projection on the photon beam axis y) by summing up pixel intensities over x from – 128 to + 128 at every y. The y-projections extracted from **(a)** – **(e)** were plotted by the black, magenta, red, green, and blue curves in Fig. 1**(f).** The curve from image **(d)** is most sharp among all the curves. It is clear from this analysis that the focusing condition depends strongly on the extractor voltage.

Fig. 2**(a)** shows the best focused image of Ne projected on the PSD. We performed the inverse Abel transformation of the projected image **(a)** and obtained the cross-sectional image **(b)**. We have then extracted the speed distribution and compared it with the theoretical Maxwell-Boltzmann distribution of Ne at 300K in Fig. 2**(c)**. The blue and the red curves indicate experimental and theoretical speed distributions, respectively. The two speed distributions agree very well with each other. The speed distributions curves extracted from the images of He, Ne, Ar, and Xe were also fitted by the Maxwell-Boltzmann distribution function to determine the temperatures. We have thereby obtained the temperatures of 427.19, 356.60, 435.40, and 450.77 K for He, Ne, Ar, and Xe, respectively. The fitted speed distribution curve of Ne is shown in Fig. 2**(d)**. The standard deviation is 41.75%. All the results given Figs. 1 and 2 manifest that our imaging setup worked satisfactory.

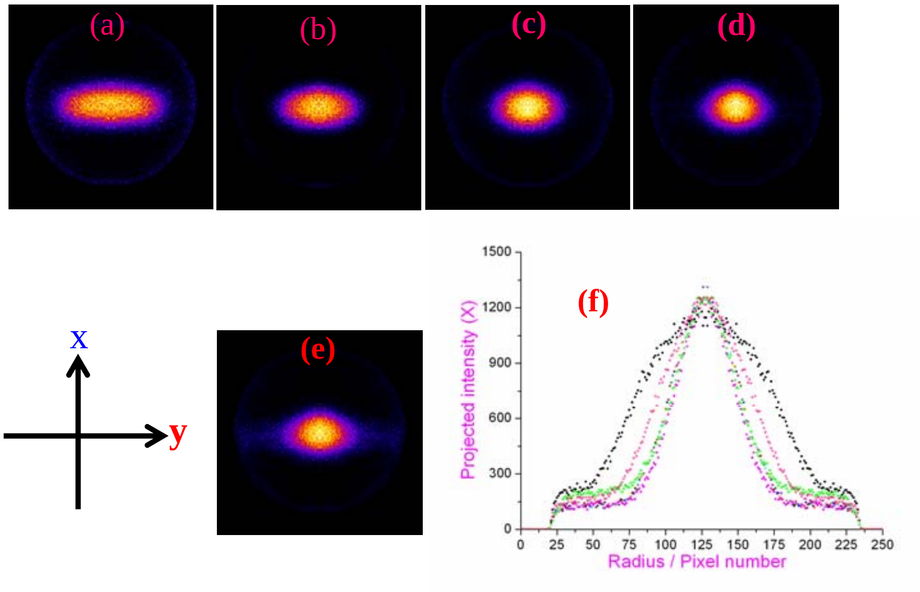
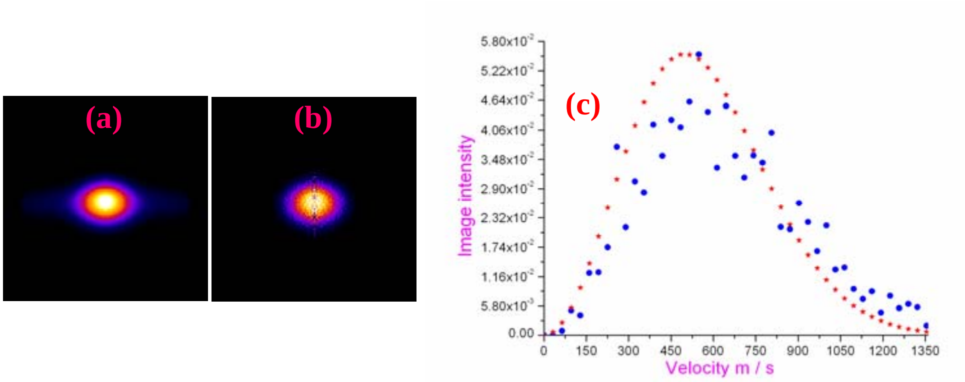


Fig. 1. **(a) – (e)** Raw 2D images of Kr on the PSD. The applied voltages to the MCP, the repeller, and the tube are –2200, 450 and –350 V, respectively. The data acquisition time is 120 s and the average ion count is ~ 2200 cps. **(f)** y-projections of images **(a) – (e).**



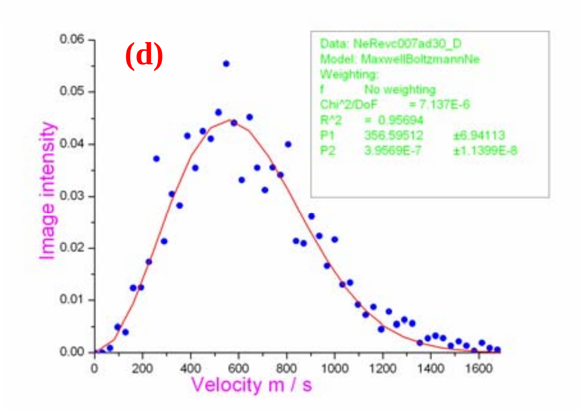


Fig. 2. **(a)** Raw 2D image of Ne on the PSD, **(b)** the cross-sectional image of the 3D velocity distribution obtained by inverse Abel transformation, **(c)** experimental and theoretical speed distributions, and **(d)** the speed distribution curve of Ne fitted to the Maxwell-Boltzmann distribution.

References

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