OPTICAL OSCILLATOR STRENGTHS OF VALENCE-SHELL EXCITATIONS OF ATOMS AND MOLECULES DETERMIEND BY THE DIPOLE (γ, γ) METHOD

L. F. Zhu[a,b], X. Kang[a,b], L. Q. Xu[a,b], Y. W. Liu[a,b], K. Yang[c], N. Hiraoka[d], K. D. Tsuei[d]

[a]Hefei National Laboratory for Physical Sciences at Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, P. R. China
[b]Synergetic Innovation Center of Quantum Information and Quantum Physics, University of Science and Technology of China, Hefei, Anhui 230026, P. R. China
[c]Shanghai Institute of Applied Physics, Chinese Academy of Sciences, Shanghai 201204, P. R. China
[d]National Synchrotron Radiation Research Center, Hsinchu 30076, Taiwan, Republic of China

Absolute optical oscillator strength (OOS) of atom or molecule, which is a very important physical quantity, represents the transition probability between two quantum states. Therefore, exploring new experimental method to determine OOS is very useful and significant. Herein we proposed the dipole (γ,γ) method to determine the absolute OOSs of atoms and molecules with high accuracy for the first time. In the dipole (γ,γ) method, the high energy photon impact (~10 keV) is used and the dipole approximation condition of $q^2 \approx 0$ (i.e., at the small scattering angle) is used to simulate the photoabsorption process. The experimental arrangement is that a beam of monochromatic x-ray photon collides with gaseous atoms or molecules and the scattered photons are analysed by a spheric grating at the scattering angle of 2° to make sure that the squared momentum transfer satisfies the requirement of dipole condition of $q^2 < 10^{-2}$ a.u..

Compared with the photoabsorption method based on the Beer-lambert law, the dipole (γ,γ) method is free from the line saturation effect that can seriously limit the accuracy of the measured photoabsorption cross-sections for discrete transitions with narrow linewidth. Furthermore, the Bethe-Born factor of the dipole (γ,γ) method varies much more slowly with the excitation energy than that of the Electron Energy Loss Spectroscopy (EELS) method. So more accurate absolute OOSs can be determined by the dipole (γ,γ) method. With the independent normalization procedure, we measured the absolute OOSs of valence-shell excitations of helium, argon, nitrogen and carbon monoxide with the present dipole (γ,γ) method and compared them with the previous experimental and theoretical results[1-4]. These results show that the dipole (γ,γ) method provides a reliable approach to obtain the benchmark data of OOSs of valence-shell excitations for gaseous atoms and molecules.

References

[1] L. Q. Xu, Y. W. Liu, X. Kang et al., Sci. Rep. 5, (2015) 18350

[2] Y. W. Liu, X. Kang, L. Q. Xu et al., Astrophys. J. 819, (2016) 412

[3] X. Xu, D. D. Ni, X. Kang et al., J. Phys. B 49, (2016) 064010

[4] X. Kang, Y. W. Liu, L. Q. Xu et al., Astrophys. J. 807, (2015) 96