Ultravioletinių P II linijų *f*-vertės gautos iš astrofizikinių stebėjimų ir teorinių skaičiavimų

Astrophysical and Computational Oscillator Strengths for Ultraviolet P II Lines

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Most chemical elements beyond He are produced in stellar nucleosynthesis and supernova explosions. Understanding the evolution of these elements is thus fundamental to astrophysics for a number of reasons. The history of element production is directly linked to the history of star formation in galaxies. Indeed, different elements are synthesized in stars of different masses. For example, α-elements such as O, Mg, Si, and S originate primarily in massive stars, while Fe-group elements form mainly in type Ia supernova explosions. Measurements of abundances of these different elements as a function of cosmic time thus provide powerful insights for understanding how the global star formation rate and supernova explosion rate evolved with time. This history of chemical enrichment in galaxies also has implications for the evolution of the intergalactic background radiation, cosmic reionization, and even the rate of binary black hole mergers.

Furthermore, chemical evolution of galaxies has implications for even the formation of planetary systems. Abundance measurements for a vast range of ele-ments have been performed in numerous astronomical objects, including the Sun, other stars, and in the inter-stellar medium (ISM) in the Milky Way. Measurements are also available for the ISM and the circumgalactic medium (CGM) of nearby galaxies such as the Small Magellanic Cloud (SMC) and the Large Magellanic Cloud (LMC). Abundance measurements of the ISM and CGM are much more challenging for the more distant galaxies, but have still been accomplished using absorption line spectroscopy of background sources such as quasars and gamma-ray bursts (GRBs). The strongest of these absorbers are the damped Lyman-alpha absorbers (DLAs) and sub-DLAs. Studies performed using the Hubble Space Telescope (HST) in the ultraviolet and ground-based telescopes in the optical have made it possible to determine element abundances in DLA/sub-DLAs, which in fact, are the most precisely measured abundances in distant galaxies.

Abundance measurements for the volatile element phosphorus are important for measuring the metallicity in the interstellar and circumgalactic gas. However, the accuracy of these measurements is limited by the large uncertainties in the oscillator strengths of some of the key transitions of the dominant ion P II.

Using a combination of quasi-relativistic Hartree-Fock theoretical calculations and observational measurements [1], we present an updated oscillator strength of f = 0.1529 ± 0.0093 for the poorly constrained P II resonant transition at 961.401 Å, which arises from the ground electronic state $3s^2 3p^2\ ^3P_0$ to the excited level $3s^2 3p3d\ ^3D^o_1$. This result utilizes archival UV/optical spectra obtained with the Far-Ultraviolet Spectroscopic Explorer for 12 OB stars in the Milky Way and the SMC with the Very Large Telescope for a quasar with a damped Lyα absorber at z = 2.811. We also determine theoretical oscillator strengths for the P II resonant transitions at λ = 963.801, 972.779, 1124.945, 1152.818, 1301.874, and 1532.533 Å, as well as for multiple P II fine structure and excited level transitions.

The improvement in the oscillator strengths of the P II transitions will be helpful for studies of interstellar phosphorus abundances in galaxies. More accurate P II column densities determined using our results would enable more accurate determination of P depletion on dust grains, and of P abundances in the ISM of local as well as distant galaxies, providing more secure assessments of the evolution of metallicity with cosmic time, and thus placing additional constraints on the cosmic star formation history.

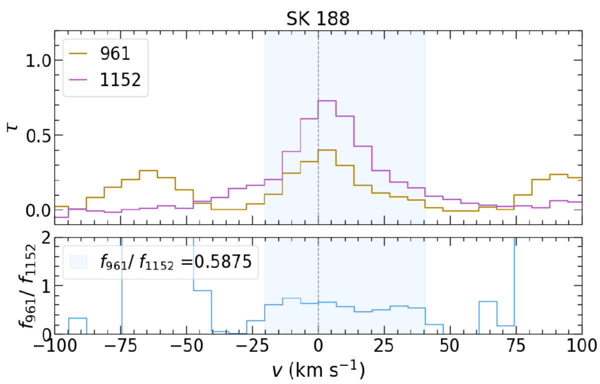

Fig. 1. Interstellar absorption lines of P II toward SK 188, a Wolf-Rayet star in the SMC. The top panel shows the optical depth profiles for the 961 and 1152 Å transitions. The bottom panel shows the ratio of the 961 profile to the 1152 Å profile. The flat region of the curve shaded in light blue was used to calculate the f-ratio of λλ 961/1152.

Reikšminiai žodžiai: laboratorinė astrofizika, ultra-violetinės linijos, atominiai duomenys

Literatūra

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