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Atomic data and collisional-radiative models of tungsten ions for fusion plasma

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Tungsten is an impurity material in fusion plasmas since it is a plasma-facing material for divertor in fusion devices and is sputtered and transported into plasmas. Because of its large atomic number, tungsten is partially ionized even in core plasmas and could lose energy due to high radiation power. To understand tungsten behaviors, a spectroscopic method is useful, and a reliable spectroscopic model is required. Many experimental and theoretical studies have been done on tungsten spectra and we have compiled much knowledge on tungsten ions, but still some data are missing.
Wide continuous two-peak spectral profile, so-called unresolved transition array (UTA) is found at 4.5-7nm wavelength region for plasma with electron temperature ˜1keV [1], produced by overlapped numerous 4d-4f and 4p-4d transitions. Many little-wide peaks at 2-4nm, produced by 4g-5f and 4g-6f transitions, are useful to estimate ion abundance for Wq+ ions with q=22-30 [2,3]. Collisional-radiative (CR) models for tungsten ions have been constructed and examined by comparing calculated spectra with experiments (e.g. [3-5]). Atomic data necessary for the CR models are generally obtained by theoretical calculations. There are several atomic codes used and calculated results by CR models give different results. It is not easy to judge which one is reliable since atomic data are huge and cannot be compared one by one. The structure of CR models is different from each other. The UTA profile at 4.5-7nm is not yet fully explained by the CR models. Much effort to improve atomic data and CR models is necessary.
Other UTA profiles are found at around 20nm, produced by n=5-5 transitions of Wq+ ions maybe with q=23-18 [6, 7]. It is necessary to construct CR models for lower-charged tungsten ions to understand tungsten behaviors in peripheral plasma and divertor regions.
If the electron temperature is higher than 3 keV, the UTA profiles almost disappear and distinct lines from higher-charged tungsten ions appear. The CR models for such ions are also examined by several groups (e.g. [8]) and are useful for plasma diagnostics from peripheral to core plasmas.

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Primary author: Prof. MURAKAMI, Izumi (National Institute for Fusion Science)

Co-authors: Dr SASAKI, Akira (National Institute for Quantum Science and Technology); Dr KATO, Daiji (National Institute for Fusion Science); Dr SAKAUE, Hiroyuki A. (National Institute for Fusion Science); GOTO, Motoshi (National Institute for Fusion Science); MORITA, Shigeru (National Institute for Fusion Science); Dr OISHI, Tetsutarou (Tohoku University); Dr KAWATE, Tomoko (National Institute for Fusion Science); Dr KAWAMOTO, Yasuko (National Institute for Fusion Science)

Presenter: Prof. MURAKAMI, Izumi (National Institute for Fusion Science)

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