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Time-dependent collisional radiative modeling and ultra-violet spectroscopy of neutral tungsten for erosion diagnosis

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High-Z materials such as tungsten and molybdenum have become leading solutions for plasma-facing materials. There are uncertainties in both erosion and transport of these elements requiring further research. The spectral emission of these high-Z species in combination with Collisional Radiative (CR) modeling can provide necessary information for plasma transport modeling. The Python program, ColRadPy, has been developed to solve collisional-radiative and ionization balance equations which can be applied to fusion, laboratory, and astrophysical plasmas [1]. The program provides generalized coefficients that can be used in existing plasma modeling codes and spectral diagnostics.

A spectral survey of tungsten emission in the ultraviolet region was conducted in two experiments, DIII-D tokamak and Compact Toroidal Hybrid (CTH) torsatron, to assess the potential benefits of UV emission for tungsten erosion diagnosis. A total of 53 neutral tungsten spectral lines were observed, including 32 lines not previously reported at fusion conditions [2]. Metastable level populations of neutral tungsten can impact both emission and erosion measurements, which can be significant at ITER relevant divertor electron densities. Observation of spectral lines in the UV region allows for relative metastable fractions and electron temperature to be diagnosed at the erosion location. The observed neutral tungsten emission lines can be used to measure gross tungsten erosion. The simultaneous observation of neutral tungsten and singly charge tungsten lines can estimate net erosion and the fraction of tungsten that is re-deposited.

Spin-changing collisional rate coefficients for metastable levels allow for the detailed exploration of the dynamics of metastable levels [3]. Long-lived metastable states in neutral tungsten can impact erosion measurements, so time-dependent collisional radiative modeling is used to analyze their role in tungsten emission and ionization. The large number of non-quasistatic atomic states in neutral tungsten can take milliseconds to reach equilibrium, affecting erosion measurements, so a scheme for measuring relative metastable fractions is proposed through simultaneous observation of multiple ultraviolet spectral lines of neutral tungsten. The Chodura sheath is a region of low electron density produced by magnetic fields impinging on plasma facing surfaces at shallow angles. The Chodura sheath also is important due to its potential impact on time-dependent neutral tungsten [4]. A simple model is developed to account for the effects of the Chodura sheath on the time-dependence of neutral tungsten. The study provides a roadmap for modeling the spectral emission from complex species like tungsten and yields accurate tungsten erosion.

References

1. C. A. Johnson et al. 2019 Nucl. Mater. Energy 20 100579
2. C. A. Johnson et al. 2019 PPCF 61 095006
3. R. T. Smyth et al. 2018 Phys. Rev. A 97 052705
4. C. A. Johnson et al (2020, November 9–13) Diagnosing metastable populations in fusion edge plasmas using collisional-radiative modeling constrained by experimental observations 62nd Annual Meeting of the APS Division of Plasma Physics

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