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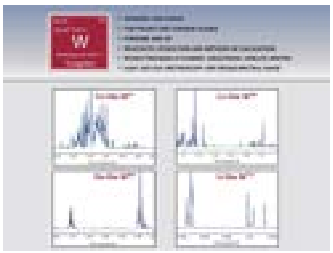
Atomic physics, spectroscopy and fusion applications of tungsten

Tungsten is a high atomic number, mass and density metal (W, Z=74, 183.84 amu and 19.3 g/cm^3 respectively) that was extensively studied and has been found to have a lot of applications in atomic, nuclear and plasma physics, chemistry, biology as well as in industry, since its discovery in 1781. Tungsten is now considered one of the best candidate materials for fusion reactors: it carries heat away efficiently, has the highest melting point of all metals and has low sputtering yield and tritium retention. In addition, recently a W divertor was implemented in the ITER (International Thermonuclear Experimental Reactor) project. The presence of heavy elements in the otherwise low-Z tokamak plasma may cause radiation losses that substantially influence the ignition of the plasma. Initially neutral, the W atoms can be collisionally ionized when moving to the hotter plasmas and it might become possible that W plasmas can reach the reactor core where they attain very high temperatures. Hence, tungsten will radiate a very broad spectrum from a few times ionized up to more than sixty times ionized, which is very challenging for the interpretation, modeling and comprehensive analysis. In this talk, we consider dielectronic recombination as a very important atomic process in laboratory and astrophysical plasmas and methods of calculations of W relativistic atomic data. In particular, we present the results of relativistic energy levels, radiative probabilities, autoionization rates and dielectronic satellite spectra of W in a very broad range of ionization stages from five times ionized (Tm-like W^{5+}) to forty five times ionized (Cu-like W^{45+}) to such very high ionization stages as seventy one times ionized (Li-like W^{71+}) tungsten [1-6] (see Figure). A comparison between the results from various relativistic atomic structure codes and accuracy of atomic data is discussed. Another important application of tungsten is in z-pinch physics and ICF (Inertial Confinement Fusion): wire arrays that consist of hundreds of micron- diameter W wires can be imploded at multi-MA currents and generate the highest radiation yield out of all other wire materials. Not only multi-MA but also 1 MA university-scale pulsed power generators are able to produce multiply-ionized high-Z plasma [7-8], which is illustrated in this talk for W z-pinches. Specifically, x-ray spectra from 1 to 10 Å from various W wire loads are presented and analyzed. Future work relevant to both atomic and nuclear physics is discussed. This research was supported by the National Nuclear Security Administration and the Office of Science of the U. S. Department of Energy.



Biography

Alla S Safronova received her Ph.D. degree in atomic physics from the Institute of General Physics, Russian Academy of Science (RAS), Moscow in 1986. She joined University of Nevada, Reno (UNR) in 1994, where currently she is a Research Professor. She is one of the pioneers in the application of x-ray line polarization to astrophysical and laboratory plasmas and has published more than 220 papers on atomic and plasma physics. Her former PhD students are working at Sandia National Laboratories, Naval Research Laboratory, UNR and also abroad. She organized, chaired and co-chaired the series of International Workshops on Radiation from High Energy Density Plasmas (RHEDP 2011, 2013 and 2015) and the 10th International Conference on Dense Z-pinches (2017). Prof. Safronova was the Guest Editor of the Fifth Special Issue (2012) and now of the Seventh Special Issue (2018) on Z-Pinch Plasmas of the IEEE Transactions on Plasma Science and of the Special Topic Section on RHEDP of Physics of Plasmas in 2014 and 2016.

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