DOE Plasma Science Center

Visiting Graduate Student/Post Doctoral Researcher Fellowship Report

Date:	09/9/13	
Name:	Jim Franek, Sam Nogami	
Institution	West Virginia University	
Email:	jfranek@mix.wvu.edu; snogami@mix.wvu.edu	
Advisor:	Mark Koepke	
Advisor email:	Mark.Koepke@mail.wvu.edu	
Institution to Visit:	Sandia National Laboratories	
Host:	Ed Barnat	
Host email:	evbarna@sandia.gov	
Title of Project:	Development of line-ratio technique for metastable-atom diagnostic	
Dates of Visit:	**Start:** 7/15/13	**End:** 8/15/13

Description of Project and Research Conducted:

The purpose of the collaborative effort between WVU (Mark Koepke, Jim Franek, Sam Nogami, and Vladimir Demidov), Wright-Patterson Air Force Base (Vladimir Demidov) and Sandia National Laboratories (Ed Barnat) was to make Optical Emission, Microwave Cavity Resonance and Laser-Diode Absorption measurements in the transient dynamics of a repeating step-pulsed argon positive-column discharge to test and validate the 4201/4198 angstrom line ratio technique reported by S.F. Adams et.al (Phys. Plasmas 19, 023510 2012). The line ratio technique, based on measured optical emissions of the argon 4198 and 4201 angstrom lines, yields the metastable-atom density to argon neutral density ratio as well as electron temperature. These measurements were performed during Jim and Sam's one month visit and the data collected will be analyzed in the following months. All parties involved in the collaborative visit were exposed to new techniques and methodologies in plasma diagnostics and an additional diagnostic technique was incorporated into the Barnat Lab's capabilities. The visit resulted in the further development and new validation of the line-ratio technique for diagnosing metastable-atom parameters.

The interaction made possible by the LTPSC brought together capabilities that allowed for the line ratio technique's validation that would only be possible through the on-site visit at Sandia National Labs and exploit it for pulsed discharges. Specifically, Ed Barnat provided a pulsed hollow cathode discharge and the fast diagnostic equipment necessary to study the transient behavior of the plasma. The practice of using a resonant microwave cavity to measure electron densities and electron temperatures was further developed during the on-site visit and now can be used by both parties in future experiments. The on-site visit introduced Jim and Sam to the practices, procedures and inner-workings of a national lab. Jim provided optical emission and laser diode absorption measurements while Sam provided resonant microwave cavity measurements which together formed a complete data set capable of fully validating and developing the line ratio method. The presence of two visiting students was vital in this effort as it increased the efficiency of data collection process and led to the students' deeper understanding of the physics of the experiment. Vladimir provided his expertise in the collisional radiative model which helped set the scope of experiments performed. Mark was present for the final week of data taking, project strategy and assessment, and future planning.

The primary accomplishment of the first week was the optimizing of the plasma source. The source was designed so all diagnostics could simultaneously probe the same plasma nonperturbatively. In the third week, a resonant microwave cavity technique that involves the relative shift and the broadening of the microwave cavity's resonant frequency peak, under development at Sandia National Labs, was used to measure electron temperature and electron density. In the last week, these diagnostics were used to temporally resolve the intensities of the argon emission lines, the metastable-atom density, the electron density, and the electron temperature during the transient dynamic stage of the discharge. Now, data are being compared with the direct measurements given by the validating diagnostics.

Preliminary analysis of the data appears to successfully validate the Adams et al. method, confirming assumptions that Adam et al. made to infer some of their results, and point to an important unpredicted relationship between the measured line ratio and the independently determined value of reduced electric field as a function of time. Figure 1, below, illustrates this universal relationship between the line ratio and the reduced electric field.

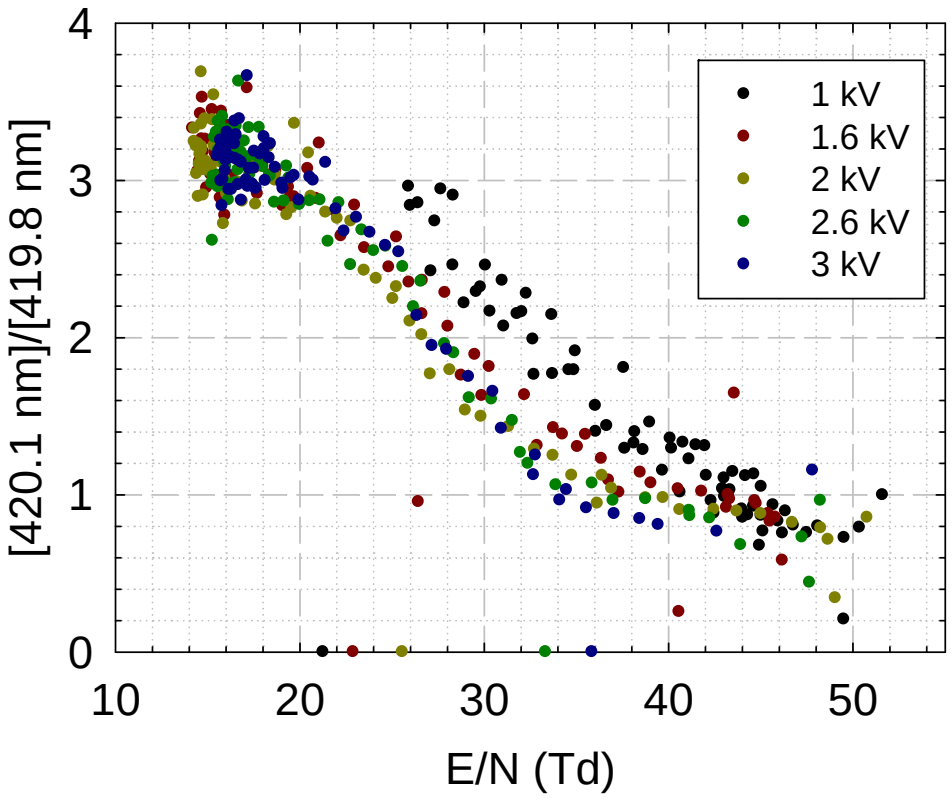

Figure 1: Line emission ratio versus reduced electric field.