Project Title: Line identifications for heavy elements of importance in kilonova modelling

Supervisor(s): David Riley, F Keenan

Email contact: d.riley@qub.ac.uk

Type of Project: EXPERIMENTAL

Helpful existing knowledge: General laboratory skills. Will use CCD and IR detectors and class 4 pulsed laser, vacuum technology.

Funding status: 3-year SFTC funded £600K grant with equipment, travel, consumables and PDRA support.

Project Description

In recent years the focus of attention regarding heavy element production has shifted from mainly supernovae to include neutron star mergers. Such mergers are detected by gravitational wave detectors and the optical counterparts contain evidence of heavy elements such as Au and Pt. However, there is a dearth of experimental data on emission lines from low ionisation states of such elements and detailed calculations need to be tested against measurements. This project centres of the observation of such emission lines in the laboratory. The wavelengths of these lines may then be used as input data to models simulating the optical emissions from neutron star mergers. We will be interested in the regime from about 0.5-2.5 microns, so from optical into the near-IR.

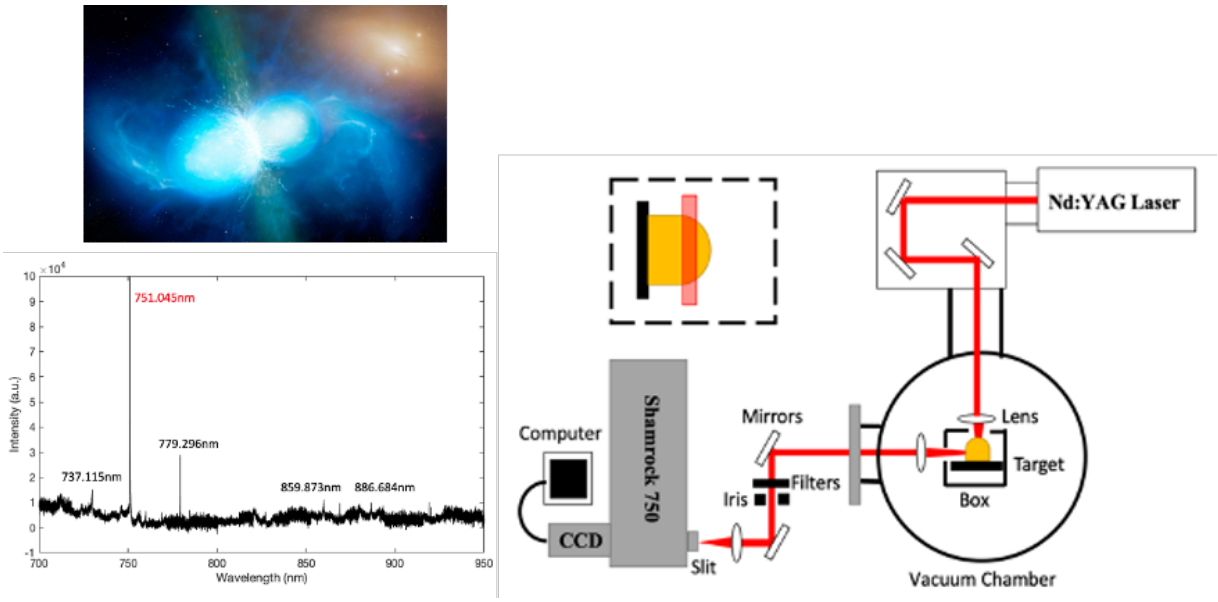

Figure 1. Top left: Artists impression of a neutron star merger. Neutron star mergers have renewed interest in r-processes which are the mechanism for heavy element production. Bottom left: Sample of preliminary data on Au (Chaurasia et al, submitted to Physica Scripta 2024). Right: Experimental set up currently used for generation of laser plasma and detection of emission spectra.

Based in QUB, the project will make use of a class 4 pulsed laser to irradiate a solid target of the desired element, Au, Pt or other metal. The laser is focussed, under vacuum onto the target, heating it to temperatures of well above 10^4 K and causing the production of an expanding plasma plume in the vacuum. This contains electrons and ions of the target element. characteristic emission lines which can be detected using a grating spectrometer coupled to a fast-gated intensified CCD camera or IR InGaAS

array detector. We will use calibrated lamps to calibrate the spectrometer and identify emission lines not yet classified in data bases such as the NIST database.

Skills gained by student

The student will gain skills in optical and infra-red spectroscopy, laser-plasma generation, operation of class 4 pulsed lasers and vacuum systems. Skills in experimental design and data analysis will also be developed.

Useful references

M. McCann et al MNRAS **509,** 4723–4735 (2022)

S.J. Bromley et al The Astrophysical Journal Supplement Series, **250**:19 (2020)