Studying the double-frequency heating mode in ECRIS plasma using Kα diagnostics

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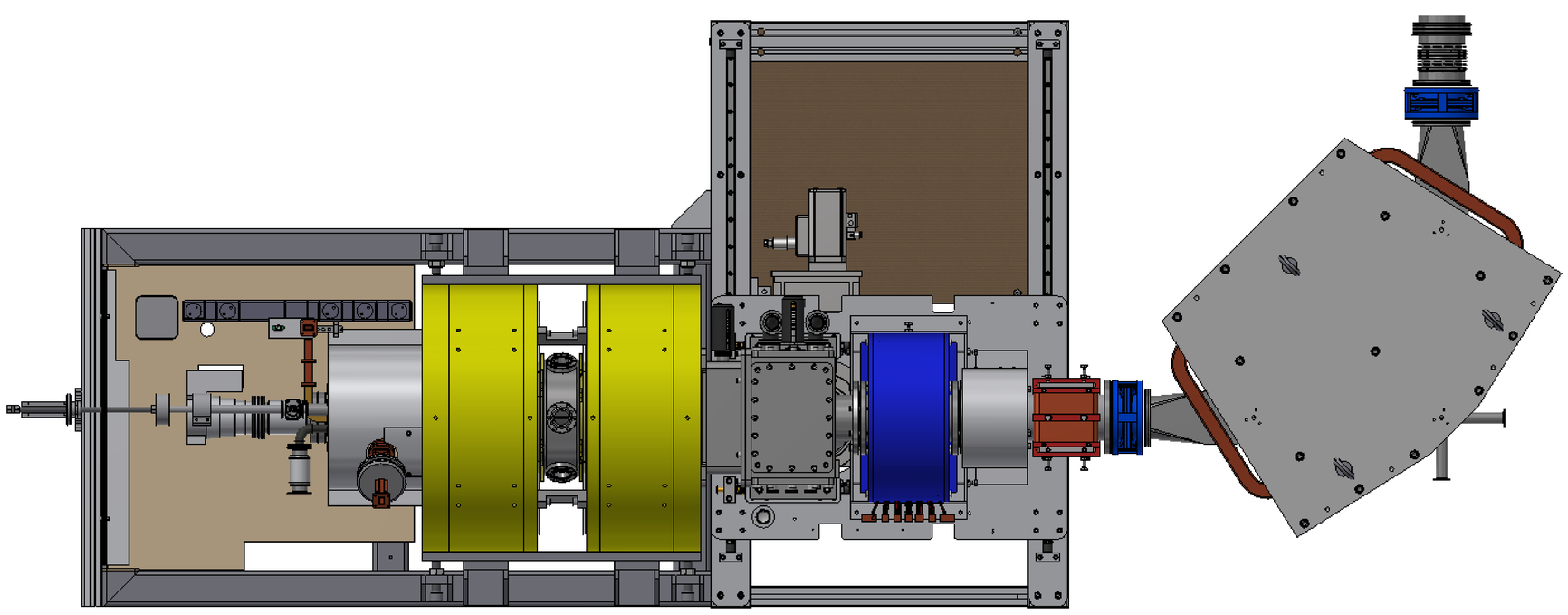
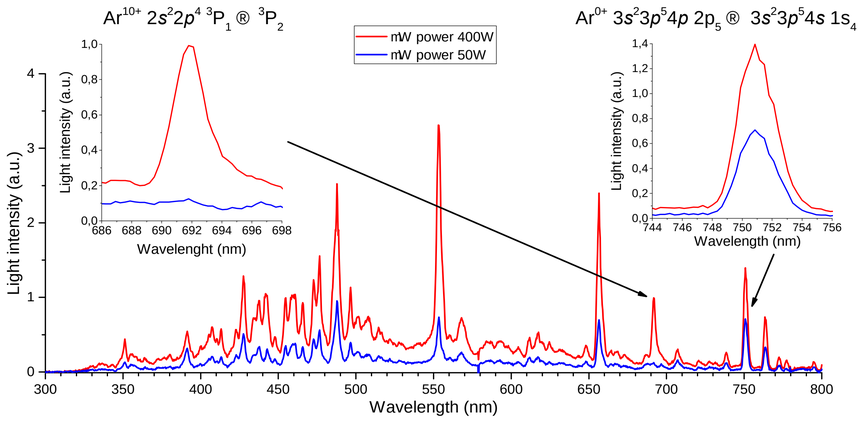
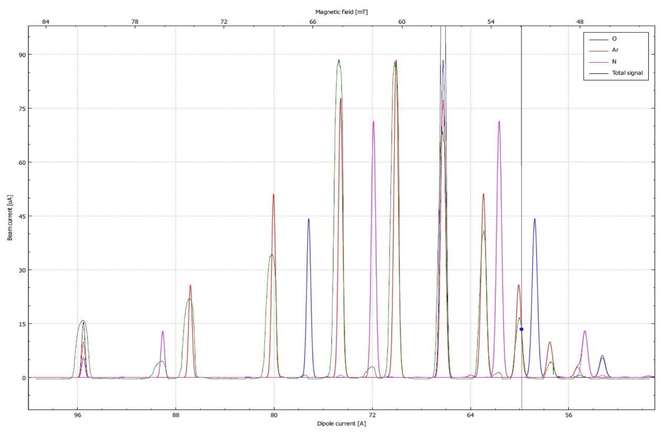
To gain understanding on the impact of double-frequency heating on high charge state production, the axially emitted characteristic Kα emission from the argon plasma of an ECRIS was measured, in conjunction with radial optical light emission from ions, as well as their beam currents. The measured Kα emission rate is proportional to the electron density, argon density (neutrals and ions) and the rate coefficient for inner shell ionization. The Kα emission allows us to assess the relative influence of the electron density and rate coefficient on high charge state production, thus enabling us to gauge the different mechanisms proposed to explain the favourable effect of double-frequency heating against the Kα diagnostics supported by the optical emission data and beam currents. Furthermore, the Kα emission rate of argon was compared to the Kα emission rate of iron originating from the stainless steel biased disc, which enables probing the effect of double-frequency heating on electron confinement and losses.

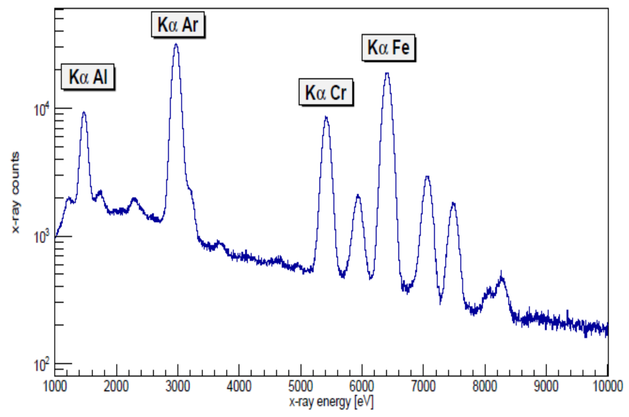


Experimental setup

The experimental setup used for this work has been extensively described previously [3] and only the main features will be mentioned here. To measure the Kα emission, the JYFL 14 GHz ECRIS [4] was utilized. This ECRIS, which is equipped with a klystron and a traveling wave tube amplifier (TWTA), was operated in double-frequency heating mode with the TWTA frequency varied between 11.100 GHz and 12.450 GHz and the klystron frequency fixed at 14.056 GHz. The x-ray detector used to measure the Kα emission was positioned to view the plasma volume and biased disc surface through a port on the vacuum chamber.





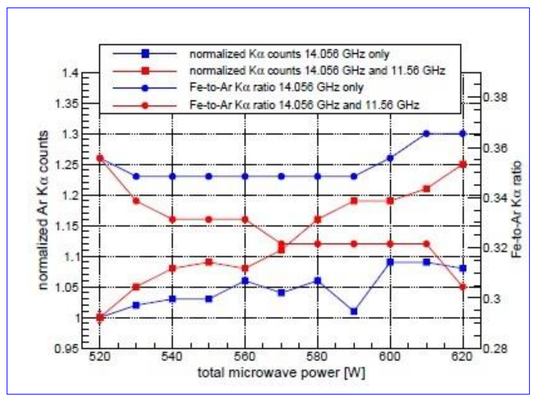


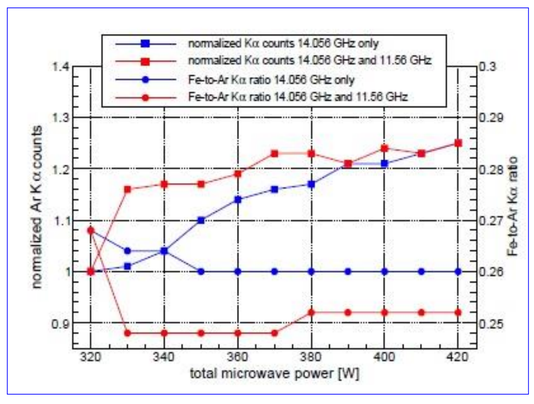
Single-frequency operation mode

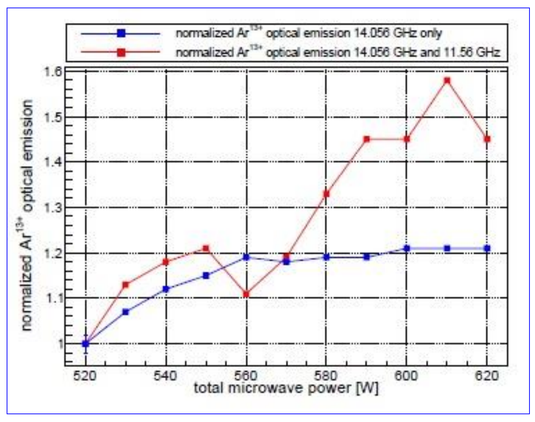
- Source optimized for Ar13+ (520 W) and Ar9+ (320 W)
- 10 W of additional microwave power added from the klystron (14.05 GHz)
- Practically no difference between Kα emission with the source optimized for Ar13+
- Practically no difference between the relative electron losses with the source optimized for Ar13+
- Practically no difference between the extracted ion beam current of Ar13+
- Very little difference in optical emission with added microwave power with the source optimized for Ar13+

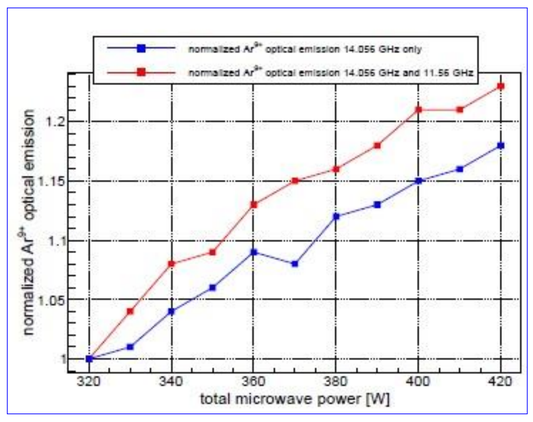
Double-frequency operation mode

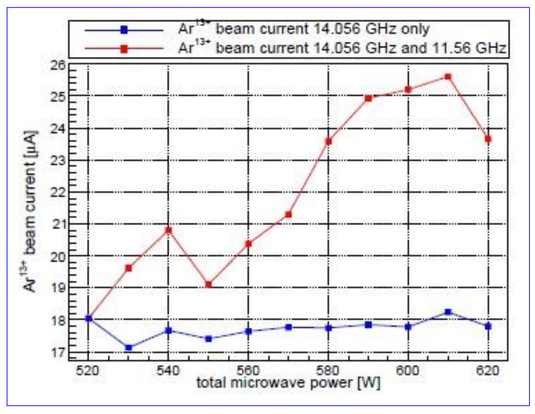
- Source optimized for Ar13+ (520 W) and Ar9+ (320 W)
- 10 W of additional microwave power added from the TWTA (11.56 GHz)
- Big difference between the Kα emission with the source optimized for Ar13+
- Big difference between the relative electron losses with the source optimized for Ar13+
- Big difference between the extracted ion beam current of Ar13+
- Big difference in optical emission with added microwave power with the source optimized for Ar13+

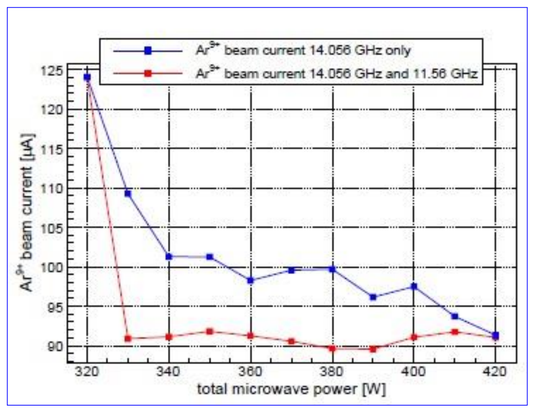












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