CEA/CADARACHE
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INSTITUT DE RECHERCHE SUR LA FUSION PAR CONFINEMENT MAGNETIQUE (IRFM)
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PhD PROPOSAL 2011

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Title : Surface temperature measurement of plasma facing components in tokamaks

Summary :

In fusion devices, the surface temperature of plasma facing components (PFC) is measured using infrared (IR) cameras, a well known method widely used. This method is especially reliable for carbon components with a high emissivity (>0.8) and therefore independent from the parasitic fluxes reflected from hot surfaces around the monitored area. Also, the Bremsstrahlung is negligible in the 3-5µm range of detection generally used with these IR cameras. However, in future fusion devices, carbon will be removed and replaced by Be and W. With these metallic walls, the emissivity is lower (~0.2-0.4) compared to carbon and/or exhibits variations over both the temperature [300-2000°C] and wavelength detection ranges [3-5µm]. In these conditions, the reflected flux will contribute to a non-negligible part of the total flux collected by the IR cameras. As a consequence, since the reflected flux cannot be separated and removed from the total flux, the classical IR thermography is not anymore a reliable method to measure accurately the surface temperature of the PFCs.

Some methods have been developed and assessed in order to measure the emissivity and/or take into account the reflected flux; namely pyroreflectometry and active photothermal method respectively. The aim of this proposal is to combine the pyroreflectometry and the active photothermal method with the standard IR measurements, for developing a method allowing the surface temperature measurement of PFCs to be carried out without any assumption on the reflected flux and the emissivity.

The active photothermal method and the pyroreflectometry will be installed and associated to an IR camera for 2D measurements on a test bed (IRFM). The first phase will consist of integrating the emissivity ratio measurement by pyroreflectometry to the active photothermal method (modulated and pulsed). The following step will consist of coupling the IR camera to the measurement allowing a full 2D picture reconstruction of the surface temperature of the sample.

The modelling part of this proposal will be devoted to the evaluation of the application range (temperature/emissivity/solid angle…) and the sensitivity of the method. A modelling of the photothermal signal will be built with the following assumptions: 3D or 2D axysymetrical, volumic absorption and emission, for a pulsed and a modulated method. Furthermore, to support the modelling task, real power deposition profile measured on tokamak's PFCs will be used (JET or Tore Supra). From this surface temperature pattern a simulation of the collected flux by an IR camera will be performed allowing an evaluation of the contribution of the reflected flux and effects of emissivities on the surface temperature measurement. Comparisons to experimental observations will be used for validating the overall experimental range of the method.

Collaboration with the University (IUSTI Marseille) for modelling activity is foreseen and first application to metallic device (JET) is also one of the goals.

Skills: Heat Physicist, Physics of materials, Scientific calculation (matlab) and plasma physics