The sun is our shining example !!

A future tokamak reactor must handle a large power load on its first wall. If this large heat flux is not homogeneous, local melting or excessive erosion of the first wall can easily occur. Mimicing the sun is one possible way out of this difficulty: creating a cold radiating mantle at the plasma boundary, just like the chromosphere of the sun.

On TEXTOR-94 this idea has been successfully demonstrated by seeding a well-chosen (small) amount of Ar, Ne or Si in the plasma edge. A radiating mantle results (see Figure), but in addition confinement is improved drastically and becomes linearly dependent on the plasma density. Detailed measurements on the DIII-D tokamak have shown that the presence of the impurity significantly damps plasma turbulence. Furthermore, by careful deuterium fuelling, it has been possible to reach ELM free H–mode confinement quality at 1.4 times the Greenwald limit n_{Gr}, i.e. far beyond what was previously thought to be an ultimate density limit on tokamaks. These discharges reach high normalised beta values $ß_N$ of 1.8 , close to the beta-limit of the device ($ß_N$=2) with radiating powers in the mantle up to several MW (~70% of the applied heating power), for durations larger than 20 energy confinement times.

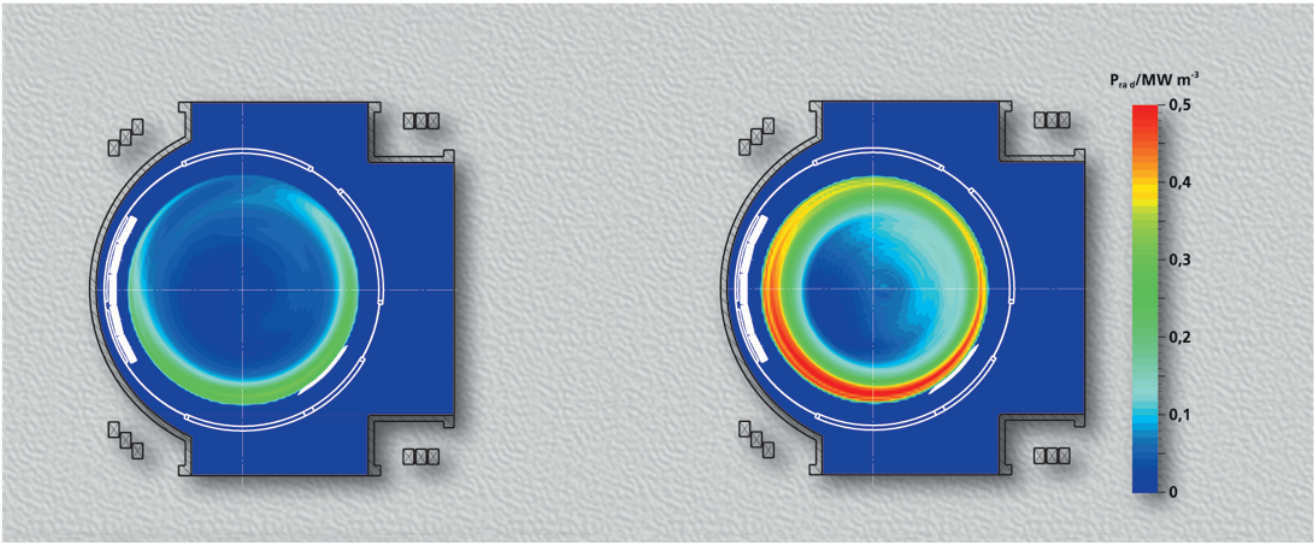
Thus, radiative mantle discharges are one way of tackling one of the main remaining problems of magnetic fusion research: realising a plasma boundary compatible with the first wall in plasmas with high confinement and high densities.

The very promising results of radiative mantle plasmas in TEXTOR-94 have been recognised world-wide, and currently nearly every tokamak is trying to reproduce these. More in particular, on the 2 largest tokamaks in the world, JT60–U (Japan) and JET (EU), the following has been obtained recently:

i) on JT60-U ELMy H–mode plasmas have now been realised at densities up to n/n_{Gr} ~65% with Ar as radiating impurity, whereas without impurity high confinement is reached only up to n/n_{Gr} ~ 40%.

ii) on JET, also with Ar seeding, outstanding combinations of density and confinement have been realised ($f_{H\,97}$ =1, n/n_{Gr} = 90%) and this for 8 confinement times or nearly 3 seconds.

These are important steps forward in demonstrating a plasma regime that simultaneously realises important requirements needed for a future fusion reactor. Contact : J.Ongena (j.ongena@fz-juelich.de).



Radiation pattern observed in TEXTOR-94 without (left) and with (right) Ne seeding. The picture shows two tokamak cross-sections. Limiter structures are shown in white. Colors reflect the intensity of radiated power. With impurity seeding, a highly radiative ring at the plasma boundary is formed. (J.Rapp, Institut fuer Plasmaphysik and Graphical Department of the Forschungszentrum Juelich, Germany)