**Heat flow from mirror to cryo-vessel as proposed by M. Doets for Adv. Virgo**

Eric Hennes, update Januari 25, 2009

The proposed geometry (as relevant for this analysis) is shown in Figure 1. The calculations are shown in Table 1 and Table 2. We also discuss the consequences for the optical performance of the mirror.

**Method.**

The netto heat transfer between two flat surfaces 1 and 2 having temperatures *T*1,2, emissivities *e*1,2 , areas *A*1,2 and mutual view factors *F*12, 21 is given by (Msc-Marc 2005 Manual A, formula 6.12):

, where *A1F12*=*A2F21*  (reciprocity condition)

For circular surfaces with sharing their axis of symmetry *F12* is, with diameters *D*1,2 and mutual distance *d* given by (Lienhard & Lienhard, Heat transfer textbook, 3rd ed., Table 10.3):



**Result.**

The expected heat transfer is about 75 mW, which exceeds the nominal absorption of beam power, which was estimated as 7.5 mW for present Virgo at full power. However, this 10 times larger power will be distributed over a 50 times larger area, as the beam diameter size is around 5 cm. In other words, the local power flux in the mirror will be relatively low. For a more precise calculation the variation in view angle for different radial sections of the mirror and the precise vessel geometry have to be taken into account. However, it is not expected that such a calculation will significantly change the estimated power.

**Consequences for mirror optics.**

The emitted power will induce an axial temperature drop across the mirror. This drop, estimated as 44 mK (see the calculation in Table 2) is hardly expected to change the mirror surface, as the emission is almost uniform, and so is the thermal distribution. Moreover, Table 2 shows that 44 mK is less than the (estimated) temperature raise induced by absorption of laser beam power in the present Virgo mirror coating. On the contrary, it is the radial variation of 70 mK at the front side (estimated by van Putten et al.) that effects the mirror optics (thermal lensing). Finally the heat transfer with the cryo-vessel is a very long term process and thus instability is not an issue.

**Conclusion.**

From the previous considerations it can be concluded that *no consequences* for the mirror optical performance are expected.

cryo-vessel

Lv

Lmv

Dv

Dm

mirror

Av-At: cold area viewed by mirror

At: transparant area

Av

Figure 1. Sketch of the geometry relevant for the mirror- cryo-vessel radiative heat exchange.Table 1 Calculation of power transfer between Advanced Virgo mirror and the adjacent cryo-vessel.

Table 2. Calculation of axial Temperature drop across the mirror due to the emitted power from Table 1.