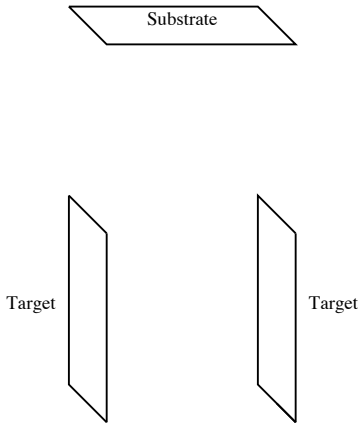
1. Radiation in facing target sputtering



Nippon Steel developed the Facing Target Sputtering method, pictured schematically above, to generate Y-Ba-Cu vapor mixture which reacts with an oxygen atmosphere to deposit a thin film of $YBa_2Cu_3O_7$ high-temperature superconductor on the substrate.

We will approximate the two sputtering targets, where the metal alloy vapor is generated, as 10cm×10cm squares, placed 10cm apart, and assume they are grey with $\epsilon = 0.4$. The substrate, where the film is deposited, is also a 10cm×10cm square, whose edges are aligned with the targets and 10 cm away from them, and assume it is also grey with $\epsilon = 0.7$.

(The nomenclature is kind of funny, the sources of vapor are called "targets" because vapor is generated there by ion bombardment.)

The primary mode of heat transfer is radiation, and assume the chamber is a black enclosure with negligible radiative emission.

(a) Using viewfactor graphs, and considering both targets as a single surface S_1, calculate the viewfactor F_{12} between the targets and substrate S_2. (Hint: it might be easier to calculate F_{21} and then use the reciprocity rule.) This is *without* the zero-flux surface pictured.

(b) Estimate the power transferred from targets at 1200K to the substrate Q_{12}.

(c) If the substrate reaches a steady-state temperature of 900K, estimate the power transferred back from the substrate to the targets Q_{21}.