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PhD position available at CRPP : *3 years starting in Oct. 2023*
Supervisor : Alexandre Baron
Subject : Theory and design of metamaterials for passive daytime radiative cooling

Decreasing energy consumption is critical to sustainable development, and temperature regulation for human comfort consumes vast amounts of energy. Substantial research efforts are currently directed towards developing thermal management techniques that cool objects, rooms, buildings or even the human body by resorting to passive approaches. One of these approaches relies on passive daytime radiative cooling (PDRC). It consists in microstructuring the surface of the body that needs to be cooled such that it acts as a white body for solar radiation, i.e. a body that does not absorb any incident radiation (see Fig. 1(a)), and as a black body in the atmospheric transparency band (ATB: 8 mm -14 mm) (see Fig. 1(b)). The resulting material absorbs none of the solar radiation and radiates all of its heat for temperatures typically encountered outdoors or inside buildings. According to *Kirschhoff's law* of thermal radiation, the emissivity of a body is equal to its absorptivity. As a result, realizing an efficient cooling structure requires a perfect absorber in the ATB. Silica is a good candidate material because it exhibits large absorption in the ATB due to phonon resonances and can come in the form of colloidal microspheres or microfibers in vast quantities. Mie resonances can be tailored to design the hybrid white body/black body property. Furthermore, these microstructures can be assembled into various materials using soft matter self-assembly techniques, either ordered or disordered in three and two-dimensions to produce coatings and textiles by weaving microfibers.

The PhD work will consist in designing realistic structured materials (*metamaterials*) that can be fabricated by self-assembly for PDRC. Various kinds of ordered and disordered arrangements of silica microspheres and microfibers shall be considered. The exploration of the parameter space will permit defining specific target materials that can be realistically fabricated by our soft-matter collaborators, characterized optically by the PhD and compared to the simulated properties. From the knowledge acquired, a comprehensive theory of structured composites for PDRC shall be sought after and how it relates to existing effective medium theories. The PhD student will work with the finite-element (FEM) based commercial software COMSOL Multiphysics to compute the properties of assembled materials, as well as with in-house built Matlab and Python Mie scattering codes for the optical properties of individual particles.

Candidates should hold an MSc in Physics or equivalent, ideally have a background in Physics simulation and have a very good level of written and spoken English.

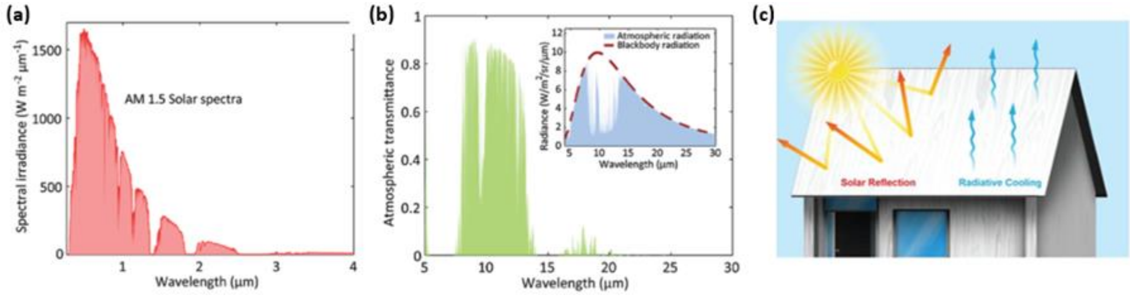

Figure 1 – **(a)** Solar irradiance spectrum. **(b)** Atmospheric transmittance spectrum. **(c)** Illustration of the principle of operation of a cooling structure for a building. Adpated from *T. Li et al., Science 364, 760-763 (2019).*