Simultaneously harvesting the universe and the sun for radiative cooling and power

Pramit Ghosh, Xinsheng Wei, Hanze Liu, Linxiao Zhu

Department of Mechanical Engineering, the Pennsylvania State University, University Park, PA 16802, United States

The sun is the source of almost all the energy on Earth and the cold universe has become an emerging renewable energy source. Daytime radiative cooling can be achieved by reflecting most of the sunlight and emitting thermal radiation through the infrared atmospheric transparency window towards the cold universe. Recent theories point out the great potential of simultaneously harvesting the universe and the sun as renewable energy sources. However, existing approaches of passive daytime radiative cooling reflect most of the sunlight to achieve sub-ambient temperature, making them incompatible with solar energy harvesting. Also, transparent emissive layer has been studied to lower the temperature of an enclosure though the achieved temperature is substantially above the ambient temperature. It will be desirable to achieve sub-ambient radiative cooling and photovoltaic energy generation simultaneously and from the same area.

In this study, we propose a dual-energy harvesting device that achieves daytime sub-ambient radiative cooling and power generation simultaneously from the same area. The dual-energy system consists of a transparent radiative cooler at the top, separated from a solar cell at the bottom. Absorptivity measurement shows that transparent radiative cooler only absorbs ~0.9% of sunlight, and most of the sunlight passes to the solar cell. Emissivity measurement shows that the cooler has high emissivity in the infrared. In experiments, the temperature of the transparent radiative cooler drops by more than 5 ˚C below the ambient air temperature under direct peak sunlight, and the solar power generation from the photovoltaic cell is 159.9 W/m^2 simultaneously from the same area. The experiment is also performed to determine the radiative cooling power that could be extracted at ambient temperature as 63.8 W/m^2. Our first demonstration of simultaneous sub-ambient radiative cooling and solar energy harvesting indicate untapped potential to utilize the two scalable renewable resources for harvesting renewable energy.