A hybrid model for the design and optimisation of thermochromic vanadium dioxide nanoparticle films

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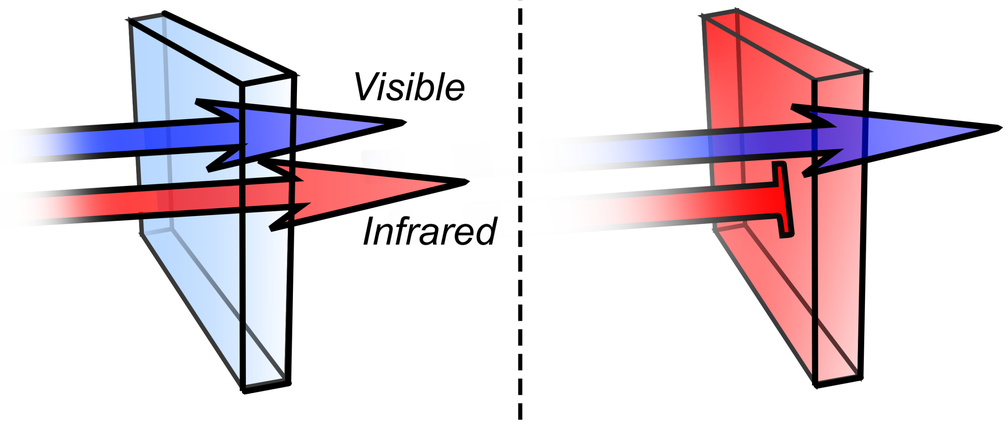
UCL

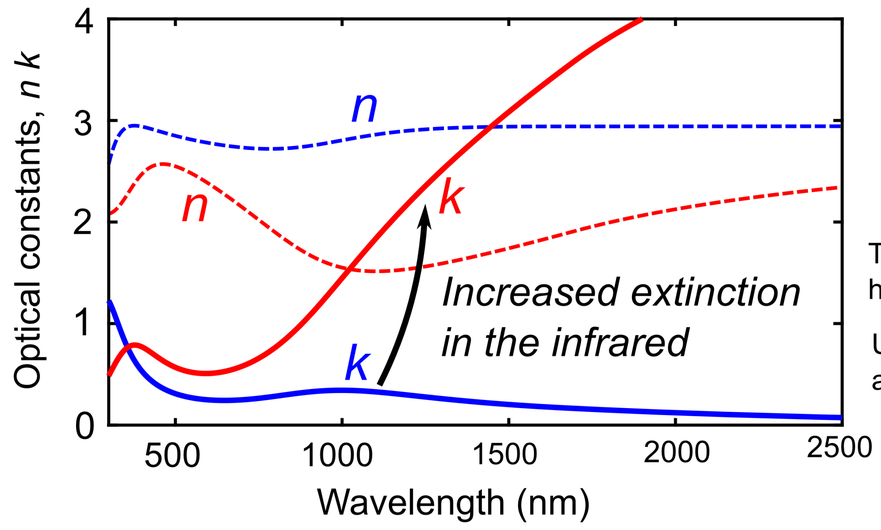
1 Temperature adaptive windows

Cold temperatures

Hot temperatures



2 Thermochromic properties of VO_2



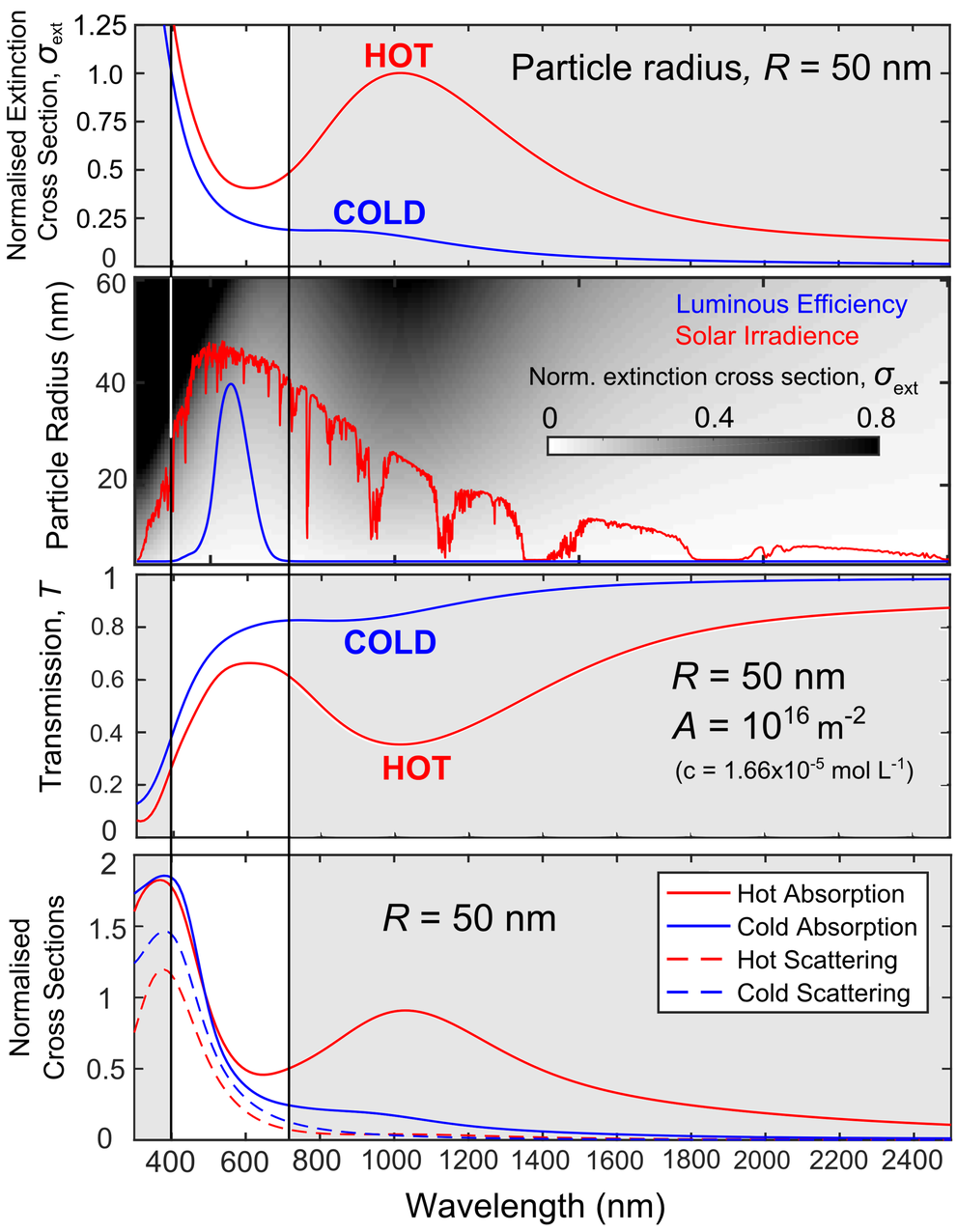
Cold: monoclinic
- larger band-gap

Hot: tetragonal rutile
- smaller band-gap

Thin film VO_2 performance is limited by high visible reflectance in the cold state.

Use of VO_2 nanoparticles embedded in a polymer avoids this issue.

3 Extinction based modulation of visible and invisible light



What's the effect of a single particle?

How are the solar spectrum and our vision effected?

... and how does this vary with particle radius?

What's the effect of many particles?

From Beer's law:

$T = \exp(-A\sigma_{ext})$

where A = number conc. x thickness

However, this picture is incomplete ...

... since it neglects the effects of scattered light.

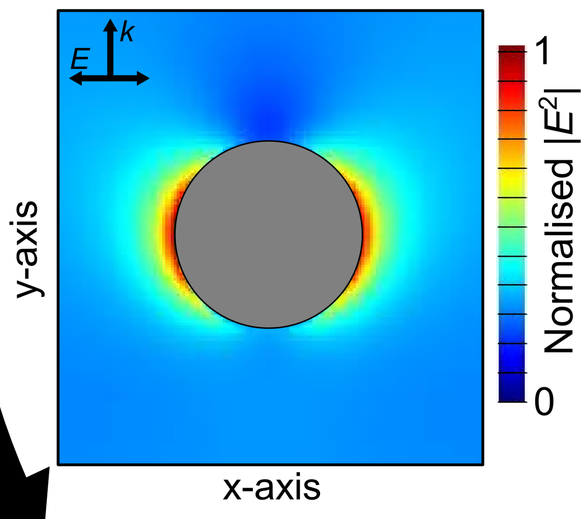
Which in the visible may result in haze.

4 Microscopic model of scattering

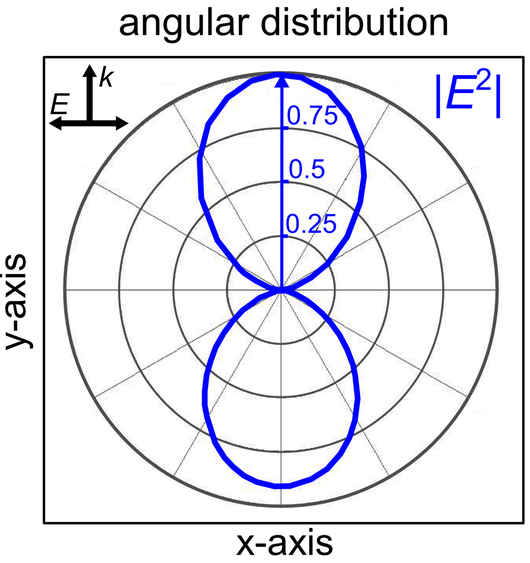
Results fed into ray-tracer

Finite-Difference-Time-Domain

Near-Field $|E^2|$ (λ = 550 nm)



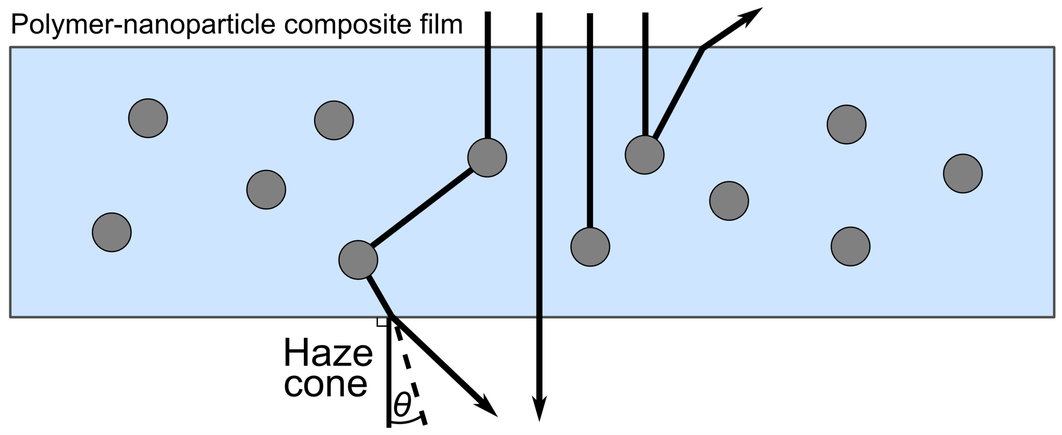
Far-Field $|E^2|$ (λ = 550 nm) angular distribution



Macroscopic model of window

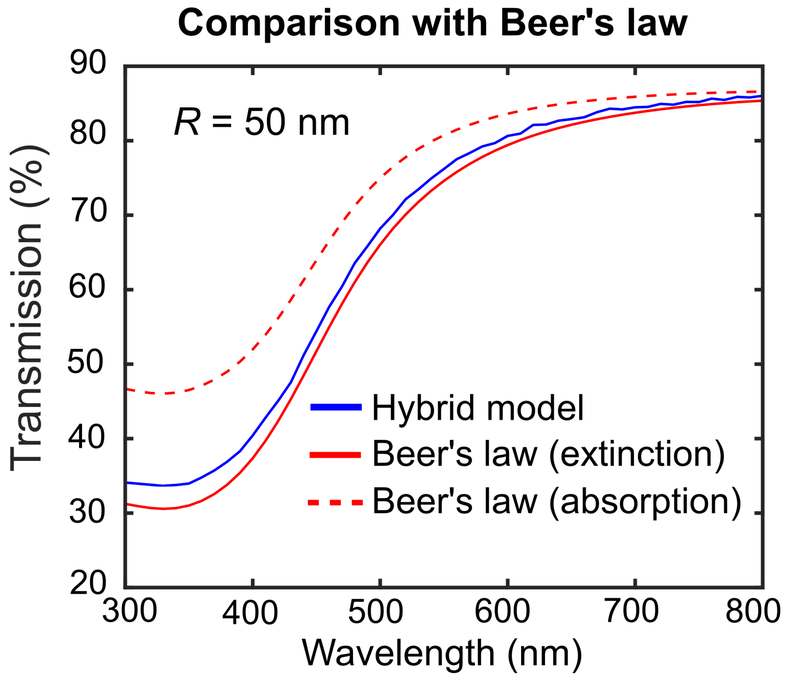
Monte Carlo ray-tracing, in 3D

Many single-photon simulations build an ensemble representation



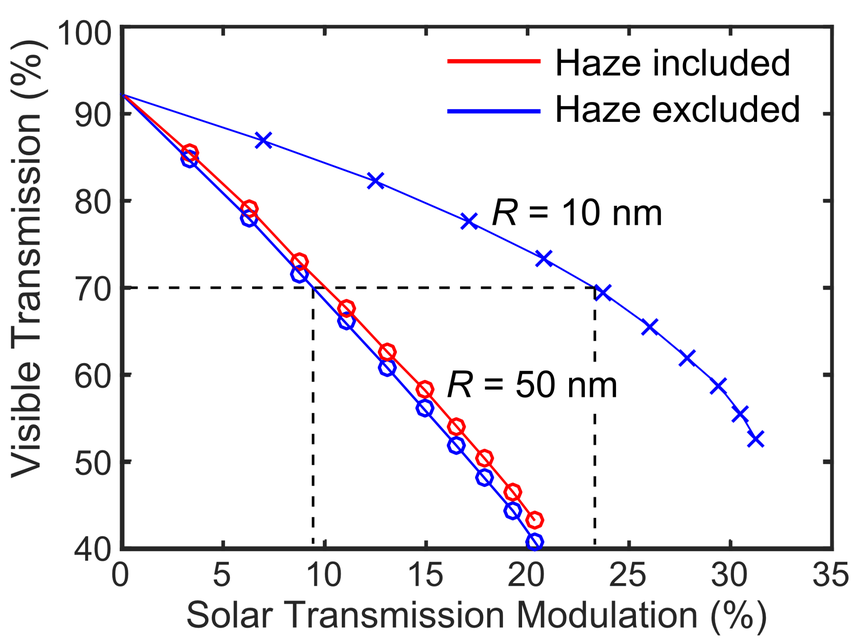
5 Combined results from hybrid model

Comparison with Beer's law



As expected, the hybrid model result is an intermediate case between Beer's law when scattering is excluded, or included in the calculation.

Simulated performance of nanoparticulate VO_2 films



Haze is defined as transmission at angles greater than 2.5° from incidence.

Each point is for a different nanoparticle concentration.

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