# Structural colour in disordered media: from photon diffusion to colour

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Structural colours arise from the interaction of light with materials structured on the nanoscale. Natural examples abound in many forms of life, from bacterial colonies [1] to mammals [2]. Among these, amorphous materials are of particular interest because of their non-iridescent colours that inspire long-lasting sustainable pigments. In these systems light propagation is governed by short-ranged order, interference, and long-ranged disorder.
Models to describe the structural colours of disordered materials have so far mostly relied on frameworks developed from single scattering, highlighting the role of short-ranged order and interference [3-7]. Here we develop a complementary model starting from photon diffusion theory, pertinent in the case of disorder. We test our model experimentally on dense and disordered packings of silica particles mixed with controlled amounts of carbon black, a broadband absorber. Our measured colours agree well with model predictions using only one fit parameter. Contrary to prior frameworks, this one is agnostic to the architectural details of the nanostructures. This makes it applicable not only to the packings of spherical particles typically made in the lab, but to any morphology as might be found in nature.

**Keywords:**
structural colour, scattering, photon diffusion, interference, bio-inspired

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