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Particle-Film Plasmons Now and in the Nineteenth-century

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Understanding how the optical response of plasmonic nanostructures is modified by the presence of a metallic substrate is a fundamental research problem relevant for many applications including biosensing, solar energy harvesting, photochemistry, and even color printing. In this work, we show that nanoparticles, which are placed in direct contact with a metallic substrate, display a charge transfer plasmon mode. Using rigorous solutions of Maxwell's equations, we find that this mode is far less dependent on the nanoparticle morphology than traditional dipolar modes. Equipped with this knowledge, we study the optical properties of daguerreotypes, which are recognized as the earliest photographic technology. Unlike other forms of photography, daguerreotypes owe their image to the interplay between specular reflection from their silver surface and the plasmonic response of the multitude of metallic nanoparticles on that surface. The results of this work not only provide an understanding of the scientific mechanisms behind the unique optical effects observed in these early photographs, but also provide insight into the development of preservation protocols required to preserve them.