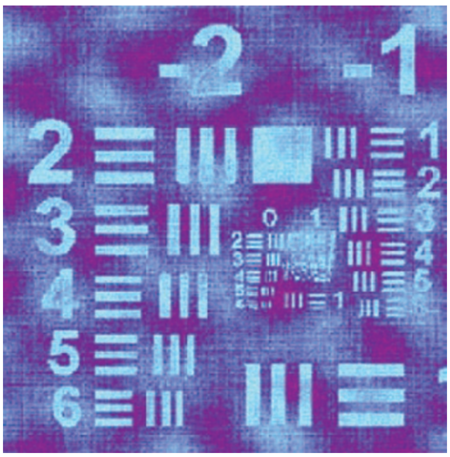
in the opposite direction. Traditional solid-state optical isolators include Faraday rotators, which provide isolation by rotating the polarization of a light beam. Now, Jung-Tsung Shen and colleagues at Washington University in St Louis, USA, have demonstrated that near-complete optical isolation can be achieved at the single-photon level by coupling a quantum impurity to a passive, linear waveguide that has a locally planar, circular polarization. Their single-photon optical diode operates on individual photons, thus enabling unidirectional propagation. Furthermore, this configuration does not rely on the use of bulk nonlinear materials or quasi-phase-matching and can be implemented in various types of waveguide. The researchers have also demonstrated that the performance of their diode is not sensitive to the intrinsic dissipation of the quantum impurity. *JB*

SUPER-RESOLUTION IMAGING

Acoustic help

Opt. Express **19,** 22350–22357 (2011)



The resolving capabilities of far-field optical imaging schemes are limited by their inability to collect rapidly decaying evanescent waves, which contain detailed spatial information. To overcome this restriction, Leonid Alekseyev, Evgenii Narimanov and Jacob Khurgin have now proposed a time-multiplexed approach for recovering evanescent waves in the far-field. In their scheme, the object to be imaged is placed in the near-field of an acousto-optic modulator and illuminated with a plane wave from a light source. Waves scattered from the object strike a phonon grating formed by the acousto-optic modulator, thereby causing the evanescent components to be shifted in both frequency and transverse wave vector. The researchers discovered that for a sufficiently large phonon wave vector, the evanescent components with high spatial frequency can be converted into propagating waves, which can then be collected and imaged. Super-resolved fingerprinting and digital holography are suggested as two example applications of this scheme. Simulations show that mixing the frequency-shifted fields with a reference wave can create a high-spatial-frequency beat note photocurrent at the detector, and that true super-resolved imaging can be achieved when the reference signal is Bragg-shifted. Although this scheme is particularly suitable for super-resolution imaging at infrared and terahertz wavelengths, the researchers say that it might also be able to work at optical frequencies by replacing the acousto-optic medium with a moving nanostructured grating. *RW*

OPTICAL NEGATIVE REFRACTION

Nonlinear solution

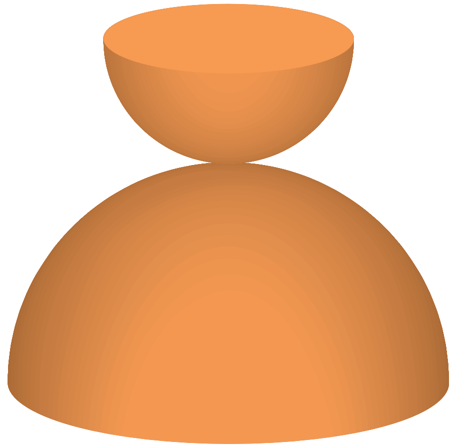
Nature Mater. http://dx.doi.org/10.1038/nmat3148 (2011)

Phase conjugation implemented via a thin nonlinear film has been proposed as an alternative to the use of lossy, narrowband and complex metamaterials for realizing the phenomenon of negative refraction, albeit at microwave frequencies. Stefano Palomba and colleagues from the USA, the UK and Israel have now demonstrated a simpler solution that operates at optical frequencies by exploiting degenerate four-wave mixing (FWM) in a 20-nm-thick nanostructured gold film. They experimentally demonstrated that a beam generated during the FWM process can emerge at a negative angle relative to the exciting wave. Mixing two plane waves at frequency ω_1 and incidence angle θ_1 with a third plane wave at frequency ω_2 and incidence angle θ_2 gives rise to two beams at a new frequency of $\omega_3 = 2\omega_1 - \omega_2$ and incidence angle θ_3 in the forwards and backwards directions. The intriguing phenomenon occurs for $\theta_1 = 0$, where the forwards nonlinear FWM beam exhibits negative refraction relative to the probe beam. The ratio between the sines of the incidence and refracted angles is a constant that depends only on the two wavelengths, which implies that the refractive index can be modified simply by tuning the wavelengths of the interacting waves. The team have experimentally shown that FWM for Au/SiO_2/Au nanodisk metamaterials is around ten times stronger than that for smooth gold film, owing to the strong field confinement at localized surface plasmon resonances. They also obtained FWM efficiencies of 9×10^{-8} for a smooth gold film and 10^{-6} for nanodisk metamaterials. The findings are potentially useful for high-resolution and background-free imaging at the nanoscale. *RW*

PLASMONICS

Optical black hole

Opt. Lett. **36,** 4311–4313 (2011)



Although the use of transformation optics and metamaterials to create optical analogues of black holes has already been suggested, experimental realization of the required material structures remains a significant hurdle. Khachatur Nerkararyan and co-workers from Yerevan State University in Armenia and the University of Southern Denmark have now suggested that spherical metal surfaces brought into contact may provide an alternative approach for investigating optical black holes. The researchers showed that plasmons with an appropriate trajectory in the gap between two metal spheres (or between a sphere and a planar surface) can be concentrated into a 'black hole' around the point of structural contact. The team used an effective-index approximation to simplify the problem, thereby reducing the three-dimensional problem down to two dimensions. In one example, they considered a 100-μm-radius gold sphere in contact with a planar surface and 800-nm-wavelength light. The effect relies on the fact that reducing the gap width increases the effective permittivity experienced by the gap plasmons, thanks to an increasing Coulomb attraction across the gap. This increased effective permittivity draws the light towards the point of contact, which therefore acts as an optical black hole. The researchers hope that this configuration can be realized in practice to allow the table-top exploration of phenomena such as Hawking radiation. *DP*

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