Acoustic camouflage: moth wings as metasurface provide bimodal stealth against bat biosonar

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Project description:
Acoustic camouflage: moth wings as metasurface provide bimodal stealth against bat biosonar. Many moths have ultrasound-sensitive ears that detect echolocating bats. Moths without ears could gain protection by stealth acoustic camouflage, absorbing rather than reflecting sound. We found that body fur (Neil et al. subm) and wing scales (Neil et al. in prep) of moths but not butterflies absorbs bat biosonar. Thick body fur is a porous absorber outperforming technical solutions. Aerodynamic constraints render the scale layer on wings too thin (<1/10th of wavelength) for porous absorption requiring resonant functionality. We found individual moth scales are resonant absorbers (Shen et al, under review at PNAS) achieving broadband metasurface functionality (Shen et al, in prep) with implications for ultrathin and lightweight solutions for building acoustics. Stealth camouflage is only adaptive in flight though. Frequently, moths are resting on substrates from which bats glean them. High absorption lets resting moths stand out as a non-reflective 'black spot', while matching substrate reflectivity would provide camouflage. We believe that the resonant wing absorber offers both functionalities – being highly absorptive in flight and highly reflective on a substrate, by exploiting the viscoelastic boundary layer that covers every solid surface. Moths would only need to adpress their wings to their resting substrate, and many species (e.g. Geometridae) do exactly that.

In this interdisciplinary project into biological metasurfaces, we will confirm and quantify that moth wings have bimodal resonant functionality by three complementary approaches:

(a) echo-acoustic tomography to quantify the boundary layer effects (details in rotation project 2);

(b) thermoviscous modelling of the absorptive properties (details in rotation project 1); and most importantly

(c) field quantification of the protective effects of absorptive coating using two experimental paradigms: We have trained a large population of wild bats to attack insects suspended from very thin threads into their flyway.

We will present a combination of intact and shaved moths and butterflies, as well as meal worms with and without absorptive coating (BASOtect foam) to measure attack rates and response distances using acoustic flight path tracking. Substrate camouflage will be tested at a large hibernaculum/swarming site near Bath, where the same set of targets plus meal worms hidden underneath intact and shaved wings are displayed and their capture rate measured. This exciting innovative project puts the emerging field of acoustic camouflage to the test, and is certain to create exciting new insights and future opportunities for the successful candidate.