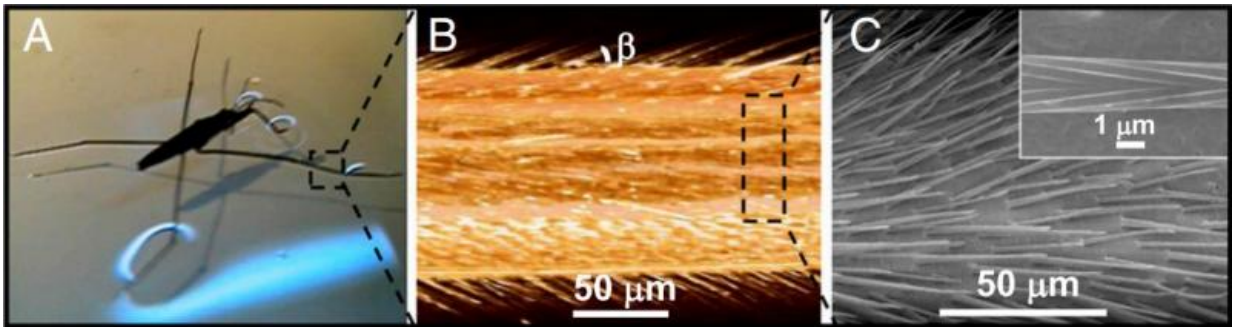
How the legs of water striders repel water

July 20 2015, by Christopher Packham



Cascade of self-motions for water droplets condensing on a leg of water strider. (A) G. remigis, an insect commonly called water strider, lives at the surface of water in a highly humid environment. (B) Micro-XCT and (C) SEM images of a strider's leg. It is composed of tilted conical setae, and nanogrooves decorate each seta (Inset). Credit: *PNAS* 2015 ; published ahead of print July 13, 2015, doi:10.1073/pnas.1506874112

(Phys.org)—Materials scientists study biology at nanoscale in order to incorporate mechanical solutions to problems that have already been resolved by evolution. This biomimicry is evident in much recent technology, including Velcro material inspired by Alpine seeds clinging to dog fur, materials with self-healing capabilities, and synthetic melanin films inspired by bird feathers.

In a technological society that evolved on a very wet planet, repelling water from sensitive surfaces is a constant engineering challenge. Recently, a group of Chinese researchers explored a natural, nanoscale

solution to the problem of water condensation, discovering the source of the superhydrophobicity of the legs of water striders. They have published the results of their study in the *Proceedings of the National Academy of Sciences*.

Water striders are bugs with the ability to run on water, bioengineered by nature to distribute their weight to long outer legs so that they are supported by water surface tension. They thrive in climates of high humidity, thus confronting an environment of both liquid water and vapor, and evolved superhydrophobic legs in order to remove the risk of saturation affecting their weight dynamics.

The researchers captured water striders in Beijing, China, and in the laboratory, made optical images with a digital video camera. They observed microstructures via field-emission scanning electron microscope. To observe the phenomenon of self-removal of water from their legs, the researchers fixed one strider leg in a chamber with high humidity and recorded the movements of water microdrops with high-speed imaging.

Antifogging materials require a force to expel water droplets from microtextures. A water strider's leg is a one-centimeter cylinder covered by an array of inclined, tapered hairs of conical shape, which the researchers imaged using X-ray computed tomography and scanning electron microscopy. The surfaces of the individual hairs have longitudinal and quasi-helicoidal nanogroves, which the researchers note increase their hydrophobicity by enhancing the mobility of drops. "Without any external force, tiny condensed droplets get removed from striders' legs, owing to the presence of oriented conical setae," the authors write. When exposed to mist, micrometric drops of water condense at the surface of the hairs, moving away from the tip and sinking down into the texture.

They stop at the base of the hair, where they continue to grow due to dynamics of condensation and coalescence. Above a critical size threshold, the droplets push away the hairs they contact, until they are suddenly expelled to the top. Drops continue to grow, and their movement is biased toward a preferred direction, which ultimately expels them from the leg surface. "All this can be understood by the ability of hairs to deform as a trapped drop grows," the authors write.

They note that drop elongation is key to this dynamic, and the typical diameter of expelled drops compares with the average distance between the conical hairs. This elastic deformation provides the energy needed for the propulsive movement of growing drops from the base to the tips of the hairs.

The authors conclude, "We anticipate that the self-removal behavior of droplets on Gerris legs will inspire the design of novel robust superhydrophobic materials for many practical applications, such as self-cleaning surfaces, antidew materials, dropwise condensers, and microfluidic devices."

More information: "Self-removal of condensed water on the legs of water striders." *PNAS* 2015 ; published ahead of print July 13, 2015, DOI: 10.1073/pnas.1506874112

Abstract
The ability to control drops and their movements on phobic surfaces is important in printing or patterning, microfluidic devices, and water-repellent materials. These materials are always micro-/nanotextured, and a natural limitation of repellency occurs when drops are small enough (as in a dew) to get trapped in the texture. This leads to sticky Wenzel states and destroys the superhydrophobicity of the material. Here, we show that droplets of volume ranging from femtoliter (fL) to microliter (μL) can be self-removed from the legs of water striders. These legs consist of

arrays of inclined tapered setae decorated by quasi-helical nanogrooves. The different characteristics of this unique texture are successively exploited as water condenses, starting from self-penetration and sweeping effect along individual cones, to elastic expulsion between flexible setae, followed by removal at the anisotropic leg surface. We envision that this antifogging effect at a very small scale could inspire the design of novel applicable robust water-repellent materials for many practical applications.