Supersonic screw dislocation

With the support by the National Natural Science Foundation of China and the Strategic Priority Research Program of the Chinese Academy of Sciences, the research team led by Prof. Wei YuJie (魏宇杰) from the Institute of Mechanics, Chinese Academy of Sciences, with members from Shanghai Jiao Tong University and Zhejiang University found that screw dislocations can glide steadily at the shear wave speed and even move supersonically in atomic systems, and those phenomena had been excluded in continuum mechanical analysis. The results were published in *Physical Review Letters* (2019, 122: 045501).

The strength and ductility of crystalline metals are in general governed by the mobility of dislocations in response to stress. Dislocations are line defects, which, from the geometrical aspect, are categorized into two types: screw dislocations and edge ones. The motion of the former leads to irreversible displacements along the dislocation line, while the motion of the latter gives rise to permanent deformation perpendicular to the dislocation line. The screw ones, in terms of their number and their activity, play a primary role in the strength and deformability of metals. However, the stress-velocity relationship of a screw dislocation and its speed limit remain unclear. The conventional theory predicts that a supersonic screw dislocation is impossible due to energy dissipation singularity.

Using molecular dynamics simulation in single crystalline copper, this group found that both the full screw dislocation and the twinning screw partial dislocation can glide steadily at the shear wave speed, and also can move supersonically—faster than the three shear wave speeds in the anisotropic face-centred cubic crystal. In addition, their simulation and theoretical analysis revealed that the stress component which does not contribute to the resolved shear stress affects the dislocation motion, in contrast to the conventional Schmid's law. This research overthrows the long-standing conventional theory that the energy dissipation for a screw dislocation moving at the shear wave speed becomes infinite, and is hence impossible. They confirm the existence of supersonic dislocation and pave the way to better understand the dynamic behavior of crystalline materials.

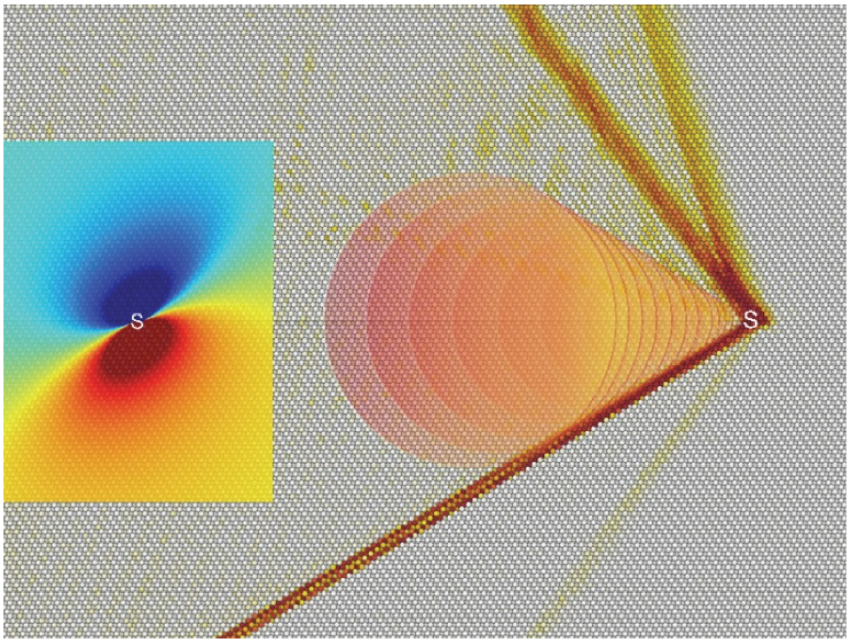

Figure The shear stress field induced by a screw dislocation (left) and Mach cones formed by the dislocation moving supersonically (right) in single crystalline Cu.