Melting of a two-dimensional superconducting vortex lattice

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Perhaps the most fundamental transition that occurs in condensed matter is melting from solids to liquids. In particular, the mechanism of two dimensional (2D) melting that has captured physicists' attention was originally suggested by Kosterlitz and Thouless. They showed that the transition is a continuous process where the structural order of the crystalline solid is gradually destroyed by means of the appearance of topological defects such as dislocations and disclinations. However, the experimental confirmation of the theoretical predictions has remained a difficult task as there are few systems which can be considered two dimensional solids. One example is found in vortex lattices in superconducting thin films. There, macroscopic measurements have provided evidence of melting close to the transition to the normal state. Nevertheless, until now the microscopic observation of this transition had not been carried out.

Here, using Scanning Tunneling Microscope, we have directly observed the whole melting sequence in a W-base superconducting thin film from the formation of the 2D lattice at low temperatures up to the transition into an isotropic liquid. Before that, we find a hexatic phase, characterized by the appearance of free dislocations, and a new smectic-like phase marked by the formation of striped arrangements of vortices. These observations could be relevant for understanding the general behavior of superconducting vortex lattices.