Examples of Cavitation and Cavitation Damage

Photographs supplied by David R. Stinebring, Eric G. Paterson, and William A. Straka

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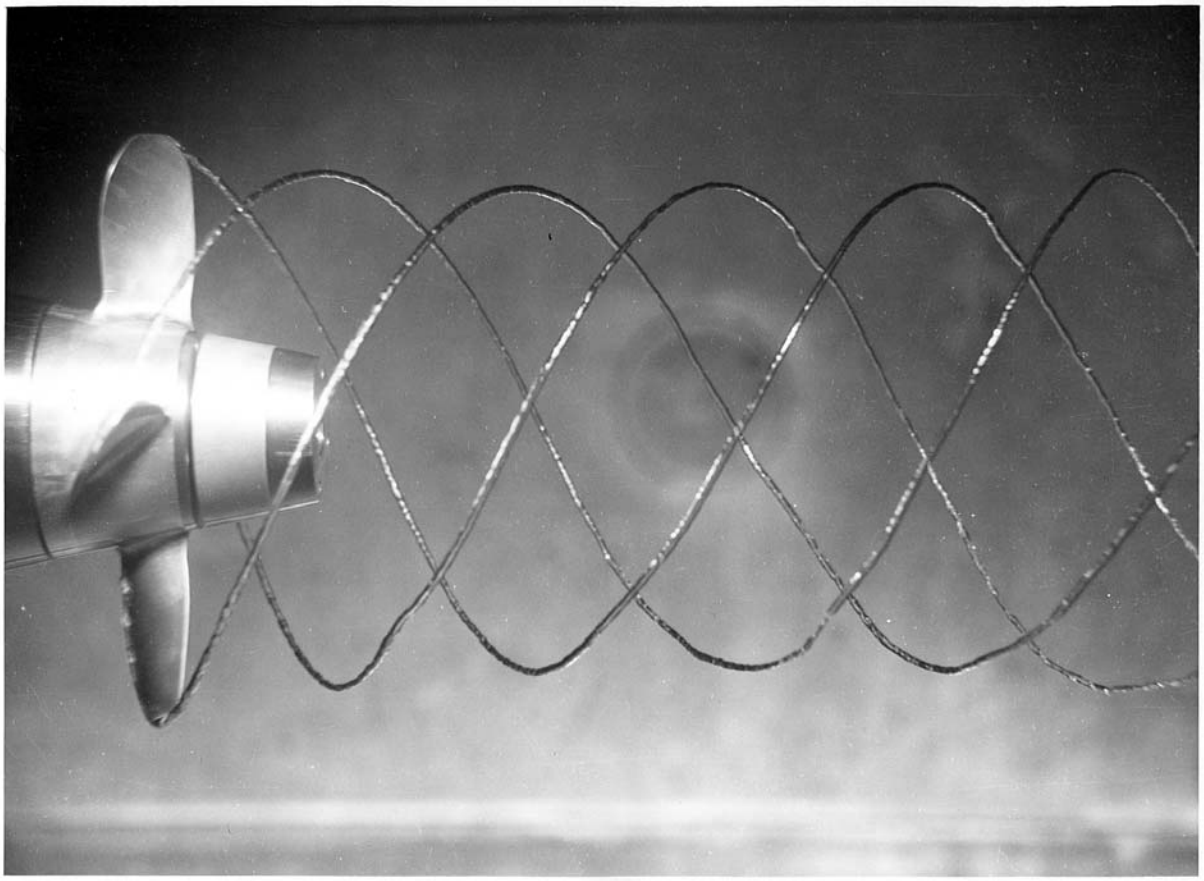
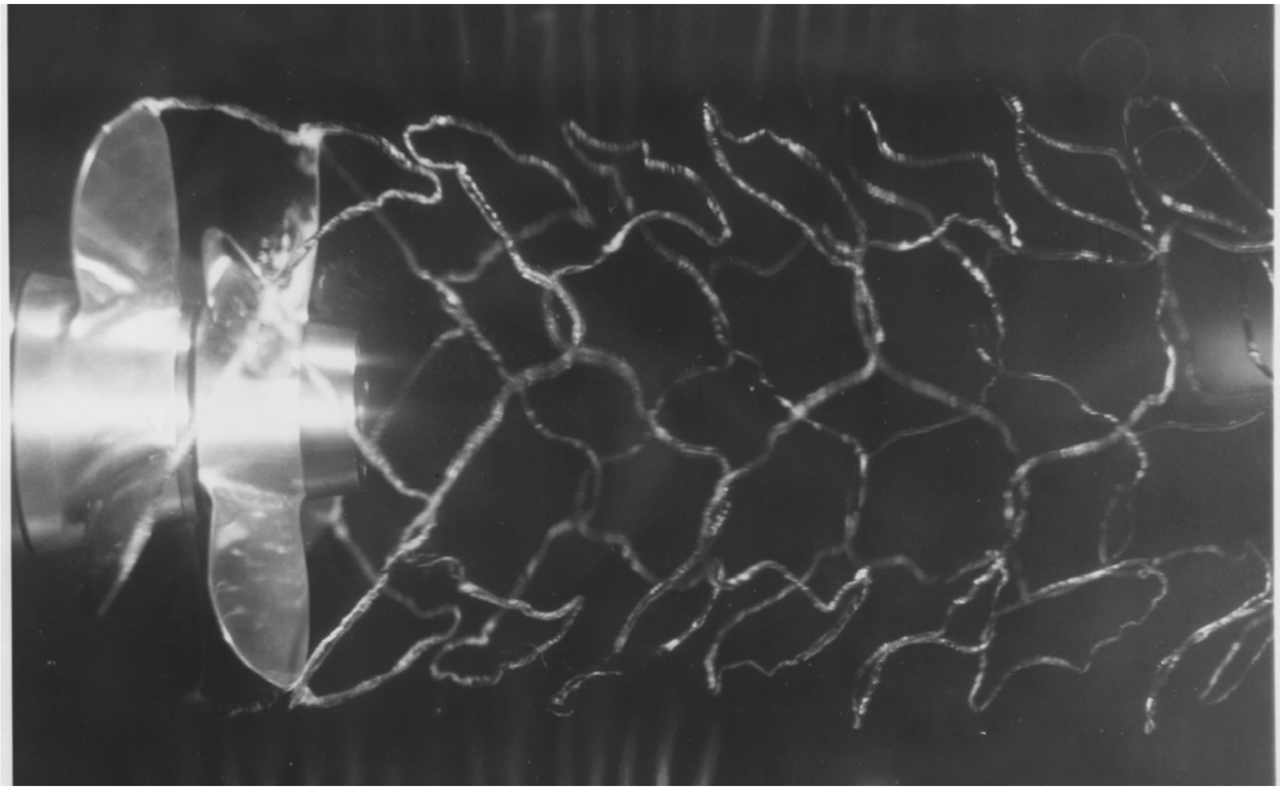
Cavitation occurs in regions of the flow where the local pressure is low enough that liquid evaporates into vapor pockets called cavities – hence the name ***cavitation***. For example, cavitation often occurs in the wake of a spinning propeller, especially near the tips of the propeller – the velocity is very high and the pressure is very low in these so-called ***tip vortices*** in the wake of the propeller, and cavitation occurs here, as illustrated in the classic figure below. Since the water is also flowing from left to right while the propeller blades are spinning, the cavitation bubbles form a helical pattern.



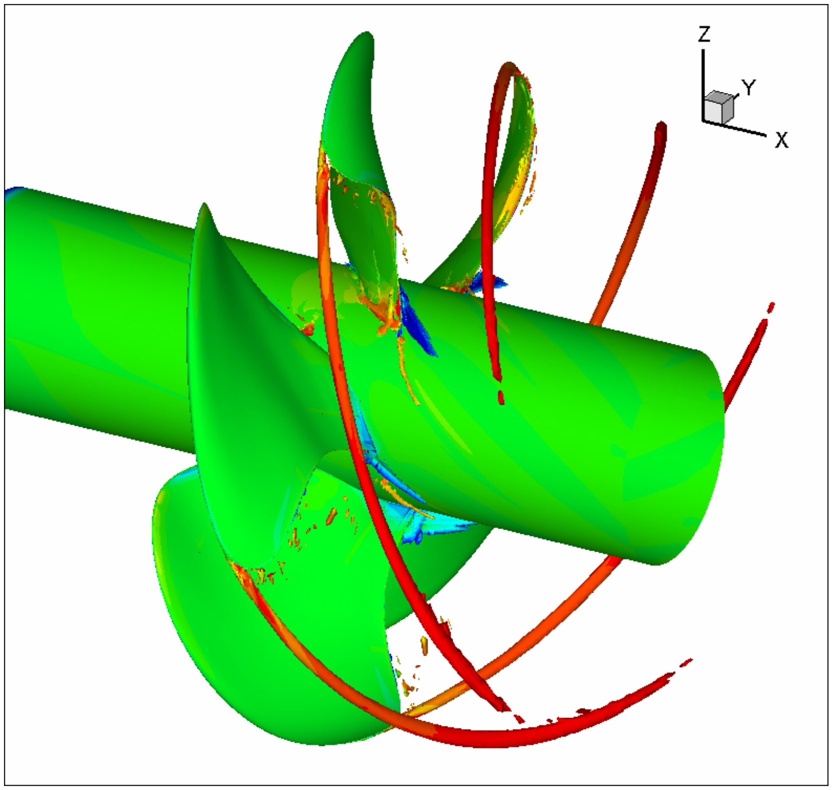
Photograph of ARL Garfield Thomas Water Tunnel tests showing propeller tip vortices.

An interesting phenomenon was observed with the cavitating tip vortices trailing downstream from a set of counter-rotating propellers. Instead of the vortices from each propeller maintaining the expected helical shape, the tip vortices from the forward propeller joined with the vortices from the aft propeller forming a series of closed loops which moved downstream with periodic spacing. This alteration of the expected tip helical vortices questions somewhat the validity of any counter-rotating propeller design theory based upon the intersection of two non-distorted helicoidal vortex sheets. This flow field would be difficult to resolve numerically with today's generation of computational fluid dynamics (CFD) software and modern computers, because it would require an enormous number of grid points (in other words, a very fine mesh).



Complex cavitation pattern produce from the tips of two counter-rotating propellers. From McCormick, B.W., "Cavitation Test Results of the Standard Mk13 Model Propellers," Garfield Thomas Water Tunnel, Ordnance Research Laboratory, The Pennsylvania State University, 1952.

CFD software can accurately predict cavitation in the wake of a single stage propeller, as illustrated below. The red regions indicate the presence of water vapor – i.e., cavitation produced in the low pressure region of the tip vortices.



CFD simulation of DTMB Open-Water Propeller Model P5168: Visualization of Tip-Vortices using Iso-Surface of Intrinsic Swirl Parameter.

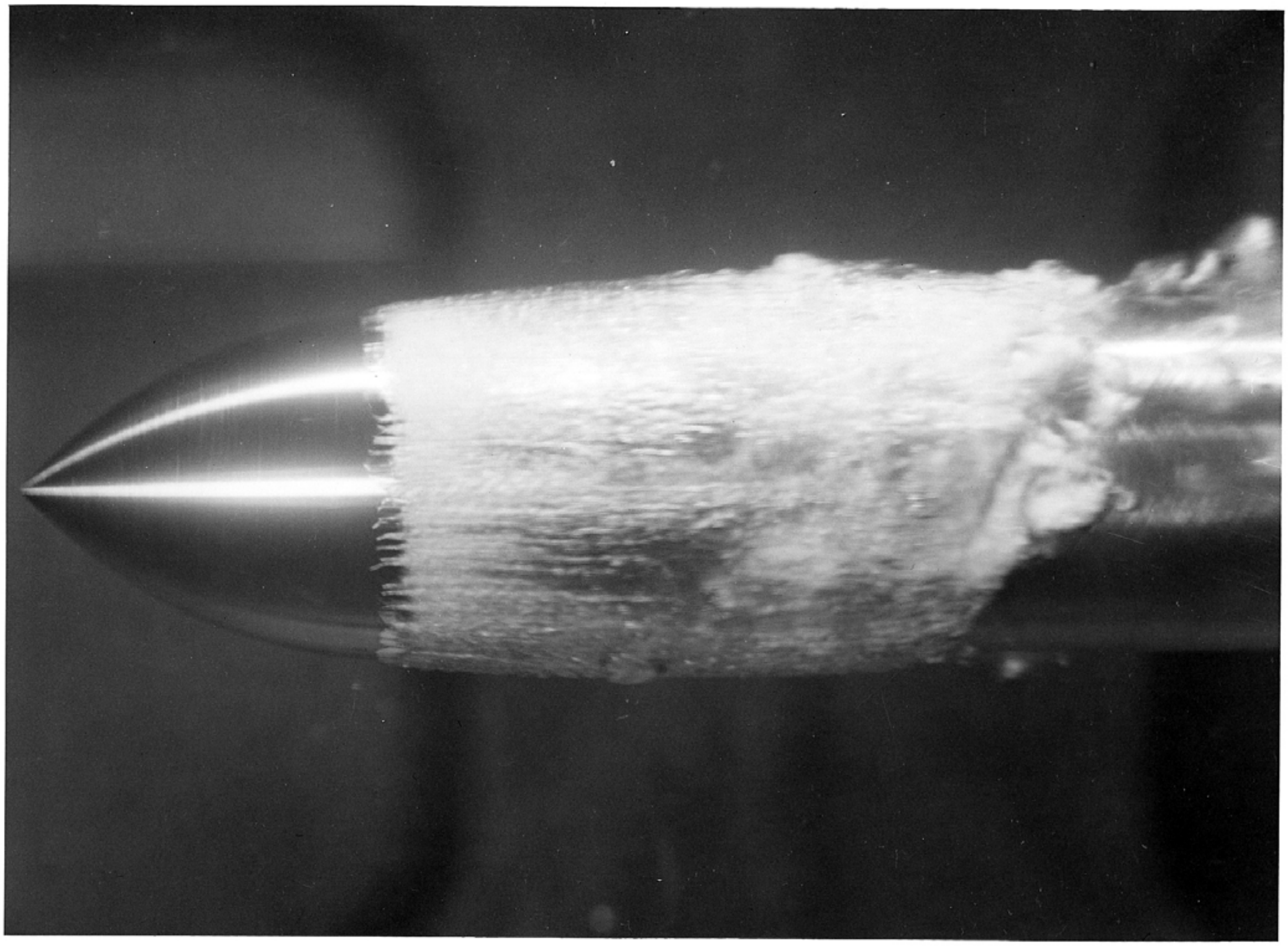
Cavitation is usually undesirable because of the noise and the damage that it does to blade surfaces (pitting, etc.). Cavitation damage occurs when the cavitation bubbles drift into a higher pressure region of the flow and collapse suddenly, leading to small but powerful pressure waves that damage nearby solid surfaces. Some examples of cavitation damage are shown in the figures below.

Photographs showing propeller and rudder relative positions.

Photographs of rudder cavitation damage.

Close-up photograph of rudder cavitation damage.

However, there are situations in which cavitation can be used to *advantage*. In conditions of supercavitation, a thin film of vapor forms between the body and the water, leading to greatly reduced skin friction drag. This enables vehicles to travel faster through the water. Supercavitation is illustrated in the following photograph, again from Penn State's Applied Research Lab.



Supercavitation along the surface of an axisymmetric body.