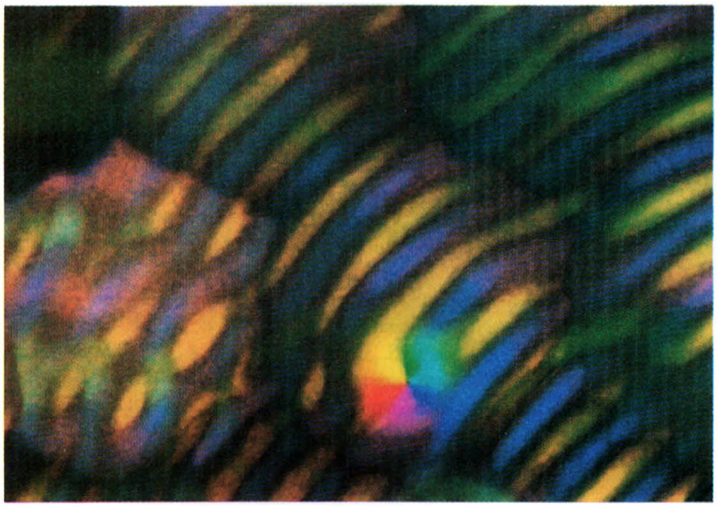

Figure 1. Vortex interaction with free surface waves. The vortex can be identified by the circle of the color spectrum toward the lower center of the picture. The wave motion is from the lower right toward the upper left of the picture.

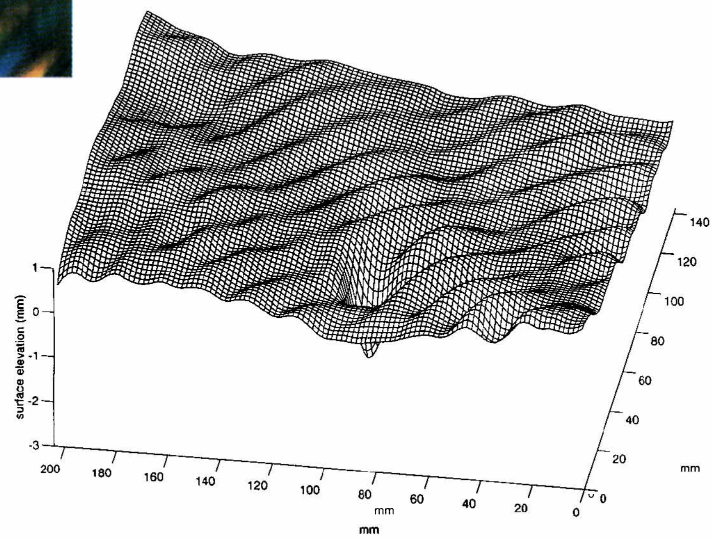

Figure 2. The surface elevation calculated from the color image shown in Fig. 1. Note that points of discontinuity appear in the waves after they have interacted with the vortex.

A NOVEL TECHNIQUE FOR FREE-SURFACE ELEVATION MAPPING

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Recently, there has been an increased interest in the interaction of vortices and turbulence with free surfaces. A central issue in understanding the free surface turbulence is to relate the surface elevation to the near-surface flow field. In that respect, the lack of a global surface mapping technique which could reveal the temporal evolution of the surface elevation has prevented the progress of viable research. Therefore, in this abstract we present a new technique, integrating optics, colorimetry, and digital image processing, to measure the three-dimensional surface elevation for a time-evolving flow. The basic idea is to color code the surface slopes by light beams of different colors. This is achieved by first using a diffused white light source to illuminate a specially designed color palette. A lens, located at its focal plane from the color palette, transforms the emerging color-coded light into a multiple system of parallel colored beams. This system of beams, after being reflected from the free surface, is finally captured by a camera. It is important to note that each color will reflect from a particular slope of the free surface. Thus, the basis of the technique lies in the fact that different slopes of the free surface are coded with different colors, through the setup of the color palette and lens as explained above. A three-chip color video camera captures the surface deformations. The images are then recorded onto three laser disk recorders for capturing time-evolving flows. Each laser disk recorder records one of the three color signals (red, green, and blue) of the camera, thereby retaining the full bandwidth of the acquired data. Finally, the images are analyzed individually with the color frame grabber residing on the computer. This analysis provides the surface slopes. The surface slopes are then treated as Fourier transforms of the surface elevation. It therefore stands that the inverse Fourier transform will provide the surface elevation. Figure 1 shows a typically captured image. The picture shows the interaction between a vortex connected with the free surface and its interaction with surface waves. The vortex connected with the free surface depicts itself as a circle of all visible colors. This is located toward the bottom center of the picture. The waves can be seen as strips of color stretching from the lower left towards the upper right. In this picture, the waves are moving from the lower right toward the upper left of the picture. It is interesting that there are points of discontinuity in the waves directly behind the vortex, after the waves have passed over the vortex. Figure 2 shows the calculated surface elevations. Here, we see the deformation of the surface due to the vortex as well as due to the surface waves. Note again that we can see the discontinuity in the waves after they have passed over the vortex.