

Preface

My first encounters with an ultra high-speed camera were two video films, which showed how a balloon is broken, when it is pricked. One movie was taken with 30 fps (frames per second) and the other with 100,000 fps. In the movie of 30 fps we see: a girl has a balloon in her left hand and a needle in her right hand. She pricks the balloon, which immediately disappears from the view. A few moments later her face is distorted and she starts to cry. It was funny to notice (sorry for the girl) the time lag between the rupture of the balloon and her frightened reaction: she was frightened, after everything had finished. So I knew that our reaction time can be measured at about 30 fps, but that the rupture of the balloon cannot be seen with this frame rate. In the second movie with 100,000 fps I saw a series of images that were completely different from my expectation. The balloon was not simply blown away, but its surface was cut into two halves. Each of them moved away from the point of needle impact, thus opening a glimpse into the inside of the balloon.

Soon afterwards I obtained more movies showing many other fast phenomena, like a destruction test of concrete, spark ignition, development of shock waves after an explosion and others. The maximum camera speed was 1 million fps. Full of enthusiasm I showed these movies to my colleagues and friends. The most popular movie was (and is) not among the movies that were taken with the maximum speed but “only” with 4600 fps: a movie of a fast train passing through a station at a speed of 180 km/h. A high-speed camera and, for comparison, a conventional video camera were installed on the platform. With the camera of 4600 fps the faces of passengers sitting in the train can be clearly recognized. In the movie taken with the conventional video camera you do not see any passengers, but the opposite platform through wide windows. After seeing this movie, many people said “Wow!” and suggested me to take images of, for example, a flying insect, movements of an eye lid, muscles of gymnasts jumping and landing, and similar scenes. In contrast to this film of the moving train they were not so excited about spark ignition or shock waves.

Why is that so? To see movements of a train, insects or our body in slow motion is, of course, interesting. However, they are just an extension of movements which we see. It is difficult to imagine something which we have never seen, not because it

does not exist, but because it is too fast to be seen with our eyes. To my offer to use an ultra high-speed camera with up to 1 million fps for testing, some of them said indeed that they have a camera which is good enough to take images of 1000–5000 fps, and that they do not need any faster cameras, because they have no processes faster than those to be seen at a few thousand fps. But how do they know that there are no faster phenomena? Isn't it worth seeking phenomena of which we do not know their existence?

This question reminds me of the electron microscope, which offers much higher spatial resolution than the optical microscope. Optical microscopes can detect only objects larger than the wavelength of visible light. Therefore, it was not possible to visualize objects smaller than the visible wave lengths, typical for most of viruses, even though one was sure that something smaller than bacteria causing diseases had to exist. Therefore, they tried to find the objects which were not detectable by optical microscopes. And finally electron microscopes were invented, and one was able to observe viruses.

Analogous to the spatial resolution, we can expect something to see, which we do not see yet, by using equipment of higher temporal resolution. If something (for example, an explosion) happens, we see the results (many broken pieces). To see how it happens, we need equipment which has higher temporal resolution. There would be many fast movement/phenomena/steps which we have not observed yet. With an ultra high-speed camera it is possible to observe them, something that we have never seen before.

I would like to show to readers of this volume, not only to the high-speed specialists but also to people who have no experiences with high-speed cameras, what we can see and what kind of inspirations one can get for things to be done in the future. Similar to many other excellent technical devices, high-speed cameras could be a tool like a double-edged sword. I hope that this tool will be used in science and technology for human welfare and environmental protection.

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