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STS51-D

WATER BALL COLLISION

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INTRODUCTION

What happens if a stainless steel ball hits a water ball in the weightless space of the Universe? In other words, it was the objective of our experiments in the Space to observe the surface tension of liquid by means of making a solid collide with a liquid. Place a small volume of water between 2 glass sheets to make a thin water membrane: the 2 glass sheets cannot be separated unless an enormous force is applied.

Also, fill a cup with water to the brim, place a sheet of paper on top of it, and turn the cup upside down gently: the water inside the cup does not spill out. It is obvious from these phenomena that the surface tension of water is far greater than presumed. On the earth, however, it is impossible in most cases to observe only the suface tension of liquid, because gravity always acts on the surface tension.

METHODS

Water and stainless steel balls were chosen the liquid and solids for our experiments. Because water is the liquid most familiar to us, its properties are well known. And it is also of great interest to compare its properties on the earth with those in the weightless Space.

Stainless steel balls were chosen the solids because they have perfect rigidity and also because they are affinitive for water. In choosing the solids for our experiments, we primarily sought for materials having the following 2 properties: affinity for water and water repellency. In other words, it was presumed that the collision of 2 different kinds of solids having opposite properties with water would result in the revelation of different phenomena. However, because it was impossible to produce solid balls having perfect water repellency under our tight schedule for the Space experiments, we abandoned the idea of using the 2 kinds of solids.

The dimension of the water ball was determined to be 16 mm in diameter from the volume of the GETAWAY SPECIAL, the dimensions of the apparatus used and the number of experiments on condition that the experiments would be recorded on a ½" VTR with a CCD color camera.

The dimension of the stainless steel balls is 4 mm in diameter.

Our experiments were aimed at observing and recording the following 3 phenomena:

(1) A phenomenon that a stainless steel ball passes through the water ball completely.

(2) A phenomenon that a stainless steel ball shot at the water ball breaks into the water ball but, failing to break through the latter, stays inside it.

(3) A phenomenon that a stainless steel ball shot at the water ball cannot break down the surface tension of the water ball.

The stainless steel balls were shot out at 20 varied rates ranging from 50 to 1050 mm/second. The rates were those presumed from the results of preliminary experiments on the earth to cause the phenomena in (1) to (3) above.

For details of the experimental apparatus, the reader is referred to PAR.

RESULTS

A total of 20 experiments were made. Although 6 of them turned out to be failures, the other 14 experiments gave very interesting results:

The successful experiments were made at the following rates of stainless steel balls:

50, 65, 120, 140, 155, 175, 200, 210, 230, 300, 380, 600, 900, and 1050 mm/second.

These rates, slightly deviating from the specifications, were calculated from the recorded images.

At the rates of 50 to 300 mm/second, the steel balls appeared as if breaking into the water ball. However, they failed to break into the water ball, but bounced back from the surface tension of water, to revolve around the water ball along the surface of the latter.

At a higher rate of 380 mm/second, the stainless steel ball broke into the water ball, but failing to pass through the surface on the opposite side, was caught on the surface of the water ball, and as at the lower rates, revolved around the water ball along the surface of the latter. It was a very interesting phenomenon revealing the drastic force of the surface tension of water by which the stainless steel ball was drawn back. On seeing this image, a physicist said, "I did not think water appears as if covered with such a strong membrane."

At a rate of 690 mm/second or more, the stainless steel balls passed through the water ball. At the rate of 900 mm/second, however, an interesting phenomenon was observed. The water ball, given high enrergy by the colliding stainless steel ball, shivered vigorously, and when the stainless steel ball left the water ball, a portion of water was separated from the water ball, to form 2 small water balls. One of the daughter water balls flew away in the direction at 90° to the direction in which the stainless steel ball left.

An incidental erroneous operation of the experimental apparatus resulted in an unexpected phenomenon. The apparatus were originally designed to shoot the stainless steel balls into the center of the water ball. At the shooting rate of 230 mm/second, however, the stainless steel ball deviated from its orbit, in a way as if scratching the water ball. The stainless steel ball was about to be caught by the water ball for its affinity for water, but the higher kinetic energy of the stainless steel ball overcame the affinity, to tear off the water ball, though its orbit changed greatly.

Professor Fuke at the National Laboratory for High Energy Physics, Japanese Ministry of Education, commented that "this phenomenon is an exact copy of the Rutherford scattering that occurs on collision of an α-particle with the atomic nucleus."

Nuclear physicists are greatly interested in the results of our collision experiments, because the experiments presented the reactions of atomic nuclei macroscopically. For example, they used to think only in mind that when an atomic nucleus composed of protons and neutrons collides with another nucleus, part of the former is attached to and revolves around the latter, while our experiments have visualized this phenomenon.

The stainless steel ball, when caught by the water ball, becomes stable in a state that the one-half portion of it is sunk in the water ball so long as it is observed in the recorded image. Why does it behave that way? When a stainless steel ball has touched the water ball, the surface tension of the water ball applies a force to draw the stainless steel ball into the water ball, while the water ball itself tries to push out the stainless steel ball that has sunk into it with its water pressure. The directions of these 2 forces are opposite to each other, and they were balanced when the one-half portion of the stainless steel ball sunk. This This reasoning was demonstrated by calculation. This balancing point does not vary with the specific density of the luquid and that of the metal ball. In other words, this phenomenon has resulted from only the surface tension of water.

CONCLUSION

Analysis of the results of our experiments are still under way. I would like to conclude this report, believing that the imaged results of our experiments in the Space will provide further interesting facts.