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Educational Activities Related to Satellite Laser Ranging at Hitotsubashi University

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Abstract. *Satellite/Lunar Laser Ranging (SLR/LLR) is full of educational materials. We present examples actually practiced at Hitotsubashi University. Although Hitotsubashi University has no department of science or technology, SLR/LLR and its components have been actively introduced in lectures such as "Earth Science I/II" (approx. 70 to 150 students for each), "Junior Seminar" (8 students; 1st and 2nd grade) and "Senior Seminar" (3 to 7 students; 3rd and 4th grade). In addition to the overview of the large-size class lectures, the interactive teaching in the small-size seminars is focused. We have invited guest speakers at the university or connected globally via Skype, and we have also visited a laser ranging station located nearby.*

Introduction

The basic concept of SLR/LLR measurement is simply the round trip of photons between a ground station and a satellite. Such simplicity is very nice for education at universities. This paper presents some examples of actual educational activities at Hitotsubashi University from 2007 to 2013.

Hitotsubashi University consists of faculties and graduate schools on humanities and social sciences, and does not have those of natural sciences and technologies. Nevertheless, it offers a number of lectures on natural sciences mainly for undergraduate students. The Geoscience Laboratory (T Otsubo and M Kobayashi) are in charge of teaching courses such as large-class lectures “Earth Science I” and “Earth Science II”, and also small-class “Junior Seminar” and “Senior Seminar.”

Course “Junior Seminar”

For the first and second grade students, we provide a “Junior Seminar” course. A small experimental room is assigned and the number of enrolled students is limited to 8. Among about 20 different experiment-based lectures, the following ones are directly related to SLR/LLR.

The first example is “do-it-yourself” work of a corner cube reflector (CCR). The students in this class firstly learn that the retroflection of a CCR is realized by triple reflection at the back faces. A “cuttable mirror”, scissors, and an adhesive tape are then arranged. Students are told to clip three pieces of isosceles right triangles from a large sheet of the cuttable mirror, and to build a CCR by adhesive tape so that the dihedral angles are close to 90 degrees. The sequence is summarized in

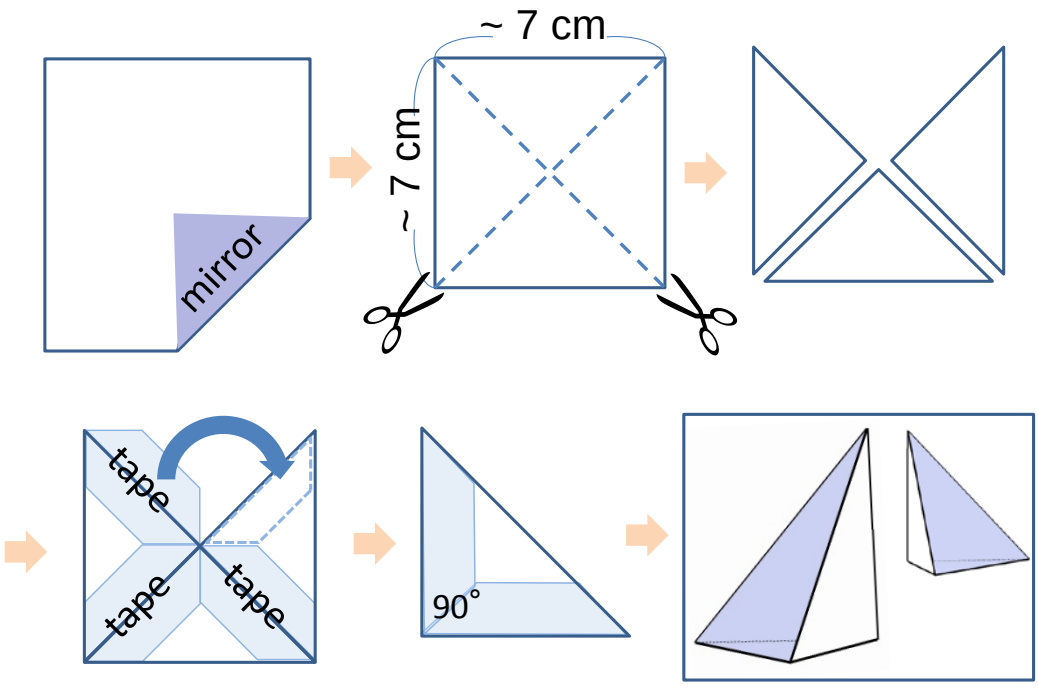

Figure 1. Instruction of hand-making corner cube reflectors.

Figure 2. Quality checks of the hand-making corner cube reflectors. Left: pointing a laser beam. Right: taking a photograph.

Fig. 1. It is of course impossible for students to make a CCR that matches the precision of commercial products, but it can still be tested by illuminating a beam from a laser pointer or by taking a photograph (Fig. 2). The students are encouraged to build a CCR as precise as possible, and their products are compared each other.

The second example is real and virtual visits to SLR stations. It is usually arranged after learning what SLR measurement is like including the hand-making of CCRs. NICT's Koganei headquarters is easily accessible, about 45 minutes by train and foot from Hitotsubashi University. Its 1.5-metre

Figure 3. Remote lectures. Left: G M Appleby from Herstmonceux. Right: Daniel Kucharski from Graz.

telescope and its time and frequency facility are the state-of-the-art technologies, and they always strongly attract young students. Our classroom had been connected twice overseas via Skype, to Herstmonceux, UK in December 2007, and to Graz, Austria in November 2010 (Fig. 3). These classes in the evening in Japanese time were given remotely from the European stations in the morning. Using a laptop computer equipped with a web camera and a microphone, each component of these SLR stations were explained and the actual ranging scenes were also seen from the classroom. Language is also a challenging factor for the students, because they are requested to use English when they give a short report and ask questions to the remote lecturers.

There are a number of other experiments and exercises in the related fields, such as satellite orbits, time and frequency, GNSS, astrography, etc.

Course "Earth Science I"

Geoscience Laboratory is also in charge of large-class lectures. There are usually 70 to 150 students enrolled to the lectures, Earth Science I and II. Earth Science I widely covers the dynamics of our planet, including space geodetic techniques. Earth Science II focuses on learning our planet in comparison with the Moon, the Sun, the planets, and other celestial bodies.

SLR/LLR is therefore placed in Earth Science I. Following its measurement concept, the technologies both in the ground segment and the space segment are introduced partly using the contents on the ILRS Website (ILRS, 2013) and the Geodesy Web Textbook (Geodetic Society of Japan, 2012). Subsequently, its ppb-level measurement precision is related to a number of small signals from the Earth. By showing a bicycle's reflector and a reflecting sheet through a microscope, they learn that our life is benefitted from CCRs.

Summary and Future Studies

Since the first author moved to Hitotsubashi University in 2007, we have strived to find a better way in education. In addition to Junior Seminar and Earth Science lectures, we have been involved in the education of the faculty level and of the graduate school level. We are also in a position to guide their graduation theses.

Considering the fact that there are not so many university teachers in the worldwide SLR/LLR community, it is vital for us to have young generation interested in our technology and science. Such educational/outreach activities should go beyond a university and even beyond a country, and it would be great if the community can globally share the educational material and the teaching resources.

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