A perspective about the total solar eclipse observation from future space settlements and a review of Indonesian space researches

D Sastradipradja[1,2] , F M Dwivany[3] and L Swandjaja[3]

[1] Member of AIPI, Indonesian Academy of Sciences – Commission for Basic Sciences, Medan Merdeka Selatan 1, Jakarta Pusat 10110, Indonesia
[2] Retired Professor of Bogor Agricultural University, Indonesia
[3] School of Life Science and Technology, Institut Teknologi Bandung, Indonesia

E-mail: dngawur@yahoo.com, fenny@sith.itb.ac.id, l_swandjaja@yahoo.com

Abstract. Viewing astronomy objects from space is superior to that from Earth due to the absence of terrestrial atmospheric disturbances. Since decades ago, there has been an idea of building gigantic spaceships to live in, i.e., low earth orbit (LEO) settlement. In the context of solar eclipse, the presuming space settlements will accommodate future solar eclipse chasers (amateur or professional astronomers) to observe solar eclipse from space. Not only for scientific purpose, human personal observation from space is also needed for getting aesthetical mental impression. Furthermore, since space science indirectly aids solar eclipse observation, we will discuss the related history and development of Indonesian space experiments. Space science is an essential knowledge to be mastered by all nations.

1. Introduction

The Sun provides energy for life on Earth through light (radiation) and heat. A total solar eclipse (TSE) gives us an opportunity to see close to the Sun. Solar studies are carried out using filtered telescopes and cameras and multiple tools to look at the solar surface and corona, the elements produced in different parts, etc. Observations are made from Earth, but watching from space is superior. It is anticipated that in LEO extra-terrestrial settlements, solar eclipse chasers who live in it will improve their observational methods, not only direct methods but also robotics due to the space hazards to human health. Solar eclipse chasers are amateurs or professionals collecting new knowledge of the Sun as well as enjoying viewing the spectacle. Above all, personal viewing to see the TSE is needed in particular for artistically impression.

2. Solar eclipse observations from Earth

Since centuries ago, people have successfully predicted and made a list of upcoming solar eclipses complete with date, time, and type of eclipse and where it will appear. The effort is very useful enabling people to make an observation program in advance. Since solar eclipses can be accurately predicted, many countries where the Moon umbra falls make efforts to invite solar observers to visit their country during the eclipse for touristic and scientific reasons. A solar eclipse is shaped when the Sun, the Moon as the obscuring object, and the Earth are aligned in a straight line and the shadow of the Moon will fall and cross the Earth [1]. The shadow covers a certain area with the center part having a TSE. In other parts of the shadow there will be a partial eclipse (PSE). Two more types of solar eclipse are known: the annular (ASE) and the hybrid (HSE) types. An ASE occurs when the Moon is too far away from Earth to completely cover the Sun's disk. A HSE occurs when the eclipse is between TSE and ASE and are very rare occasions [2]. Those events cause a group of people, the 'solar eclipse chasers', emerge who will travel to remote locations on Earth to observe predicted solar eclipses and they are not frightened experiencing difficulties. TSE can be seen from Earth or from space, in example from futuristic LEO space settlements because the angular size of the Sun seen from these points in space is about the same visual size of the Moon so that the Moon can completely obscure the Sun. TSE may exist until circa 1.4 billion years from now. By that time the Moon will be positioned too far away from Earth with an increase distance of 30,400 km due to yearly increase of 2.2 cm. This is caused by tidal acceleration of Moon's orbit around Earth. The angular size of the Moon will be too small to cover the Sun entirely and no natural TSE exist ever since [2].

3. Solar eclipses as seen from space

LEO satellites have a distance to the Sun in reasonable reach from Earth, around 250 – 1200 km from the surface of the Earth [3]. Human has always been living on Earth, but it is predicted that one day human will need more space. Living in other space beyond the Earth has been a dream of mankind since the first successful space mission. This dream led human to plan for settlements in other satellites, planets or other celestial objects. These days, LEO satellites have been constantly manned for certain mission. Hence, solar eclipse may be experienced by the crew in those satellites. The advantage of observing solar eclipses from space is that the observation setup is freed from the disturbing weather and cloud conditions. We have until to date just a few astro-cosmonauts spending a short time, a few years at the most, in space. Only these astro-cosmonauts have had the opportunity watching solar eclipses from space. A few notable events [4] are attested briefly below. The crew of Gemini XII observed a beautiful total solar eclipse from space in 1966 [5]. A theoretical possibility is making an artificial object to obscure the sunlight, but there is no way at present to make such large artificial satellite to give the "Moon caused eclipse effect". At the altitude of the International Space Station (ISS), an object would need to be about 3.35 km across to blot the Sun out entirely [1]. During the Apollo–Soyuz Test Project of July 1975, Apollo and Soyuz space crafts docked together for 44 hours to conduct collaborative space manouvers followed by separation and use of Apollo to create an artificial solar eclipse allowing Soyuz to take photographs of the solar corona [4,5]. Robotics approaches may be used due to the health hazards for life of the space environment. Much have been achieved on solar knowledge, but human presence in space is also needed for manual monitoring and repair purposes of equipment and for getting mental artistic impressions.

4. Present and future developments

If space tourism [6] will becoming less expensive and on its turn will create active space related activities, more people can enjoy traveling into space to catch the opportunity of watching solar eclipses and other celestial phenomena. Future activities will expand readily if extraterrestrial settlements are emerging. We will soon come into a situation in which the keyword of futuristic development of human civilization is making the space fit for a living habitat. It is not too early now to seriously start thinking about joining other advanced nations in preparing for the future off-Earth living habitats for mankind. The growing activities will begin with the efforts to get material needed for life such as water, oxygen, minerals, sand, building materials, primary products, and carbon, from other sources like other planets, the Moon and asteroids than from Earth. Gradually, mankind will require other services for other needs like food, housing, education and recreation as sports-entertainment. Here is where space tourism should develop. One of the most basic arguments that calls for human settlement off-Earth as a first-order priority is the survival of human civilization by creating alternative living space [7].The space dwellers are the ones who will do the space activities, among them will be the future solar eclipse observers.

NASA plans to send manned mission to Mars by 2030s [8] and subsequent building a colony SpaceX on Mars. It would take 400 years to reach a settlement of 80,000 inhabitants to ensure the required safe human genetic diversity to be established. The Mars environment will need paraterraforming which is equally [9] needed for other planets and space habitats. It costs a lot, but building a LEO space city will be more expensive; although ultimately in the future LEO cities will also be built. Experiencing TSE from Mars is not possible though, as Luna can only be seen as a tiny spot in the sky of Mars. This planet knows solar eclipses by one of its own moons Phobos which is of an ASE type having a broad ring of unobscured Sun [10]. Following the example of Appolo 12, a Mars orbiting satellite may make Mars as the object to obscure the Sun and a TSE may be seen by the viewers in the orbiting vehicle.

5. Present state of solar studies and space research in Indonesia

Research in astronomy including activities of solar studies in Indonesia have been routinely carried out facilitated by Bosscha observatory since 1923 and coordination by LAPAN (Indonesian Natiomal Space Agency). LAPAN also make a statement of its commitment to enhance space research [11]. Our discussions will continue on efforts doing space research. Interest in space research in Indonesia started around 1985, when NASA offered Indonesia to send its astronaut into space within NASA program of sending manned spaceships into space, carrying with him/her some space experiments to be conducted in space [12]. Regretfully, this plan was discontinued due to technical, financial and other constraints. Only just in the first decade of this century, the real Indonesian space experiment started to be executed.

5.1. LAPAN endorsed researchers and academics to send research materials to outer space

Due to its duty to develop space science, LAPAN is involved in a cooperation between Indonesia with JAXA in a KIBO program related to Biological Sciences. Indonesia has hosted the workshop on "The 1st Space Exploration and KIBO Utilisation for Asia", the first workshop related to utilisation space exploration for research in many fields of human activities. The Space Environment Utilization Working Group (SEUWG) plans to optimize the use of KIBO, the Japanese Experiment Module on ISS, as the way to facilitate effective joint utilization of the space environment among Asia-Pacific countries [13]. The Space Seeds for Asian Future (SSAF) program is one of the activities which utilise KIBO-AB and initiated by the Asia-Pacific Regional Space Agency Forum (APRSAF).

5.2 NASA supports space experiments by Indonesian high school students

Yeast and rice from Indonesia out into space. Two high school teams were selected to create micro labs to be sent to the ISS for research purposes. The micro labs were transported to the ISS on a Cygnus cargo ship, and subsequently the micro labs were put to use and able to be monitored from Earth in real time. The purpose of the micro labs are to study the alcohol production in yeast and paddy cultivation in zero-gravity environment [14]. The results will then be able to be used for future research. Overview of the research is that 'NanoRacks-Surya Institute Indonesia-*Oryza sativa* Growth in Microgravity Conditions' (NanoRacks-SII-Plant Growth) determines how the growth of *Oryza sativa* and its roots differs with that on Earth and affected by microgravity (MG) and lightless conditions. It also explores the methods on how to grow plants in space, specifically a staple food such as rice, which requires lots of water. This investigation explores the different needs and feasibility of growing rice in weightless, confined conditions as opposed to that on Earth. The benefit of this research is to acquire knowledge in how to cultivate foodstuffs and plants in a confined, weightless environment that is useful in supporting astronauts for planned, long-term missions. In addition, another benefit is the knowledge gained being useful in selecting suitable foods for cultivation in space. The impacts of gravity and light towards plant growth are also better explored. This knowledge leads people to develop more efficient methods of cultivating staple food like rice.

5.3 Research using simulated microgravity (MG)
ITB has built a clinostat which is subsequently used for studies with plant and seeds [15] in a weightless environment. The research was jointly carried out by ITB and LAPAN. Sastradipradja [16] built a simple rotating wall vessel cell incubator system using a kymograph which is setup horizontally carrying cell incubation tubes attached to the rotating drum. A test trial using growing goat's lymphocytes demonstrated that the system supports 3-D growth of cells.

5.4 Research soon to be initiated on metabolomics in simulated MG environment
It is the intense wish of the first author (*pers. reflections* 2016) of the present article to see an umbrella research project to be conducted by the younger generation to do research on 'Metabolomics of animals in simulated MG environment (dry immersion in water)". The young researchers are well informed of animal calorimetry techniques [17]. Metabolism is an essential function of life. Data on energy metabolic rates under MG environment can be related to functional metabolic body size and an allometric relationship between metabolic rate and body size can be formulated to give deeper understanding of the phenomenon of scaling of diverse organisms under MG environments. Metabolic studies may deepen our understanding of the catabolic reduction effect of MG on life by quantitating its value and revealing the cause of and how to manipulate them further for better bodily benefit.

6. Conclusions
Natural total solar eclipses by the Moon will continue to happen, observed by viewers on Earth and its immediate surrounding space. Viewing solar eclipses from space is superior to observation from Earth. Robotics approaches may and still continue to be employed. However, human personal observation from space is needed as a mind-stretcher. This fact coincidentally happen parallel with extra-terrestrial off-Earth accommodation. NASA's prospective plan to send manned space mission to Mars by the 2030s will find different way of eclipse (by its own moon) or only occultation. It is imperative that all nations be involved developing space science to make a space fit for life. Currently developing countries have less chance to do space-related mission or research. Nevertheless, we can use another approach to do space-related research. For example, the research on microgravity can be done using simulation on a clinostat, rotating wall vessel cell incubators or water immersion approaches.

7. Acknowledgement
The authors would like to thank Dra. Clara Yono for providing information on vision & Mission of LAPAN. Thanks are also due to Prof. J.W. Saputra, Indonesian Research Funds, Ir. Srisetiowati Seiful, MBA and Ir. Syailendra Harahap, SSI, both from the Surya Institute for briefing on the NASA sponsored Indonesian Highschool student's research. We would also like to thank the ISSEL editor and reviewer for the help and opportunity to publish this paper in proper form.

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