Comparison of Different Planet Detectors: Juno Spacecraft, Akatsuki and Perseverance Mars Rover

Yuening Ding[1, †], Heyang Weng[2, *, †], Jili You[3, †] and Yuanbo Zhang[4, †]

[1] Guangdong Country Garden School, Shenzhen, China

[2] The village school, Houston, United States

[3] Zhejiang Ninghai High School, Ningbo, China

[4] Jinzhong Peiwen Experimental School of Peking University, Shanxi, China

* Corresponding Author Email: heyang_weng@s.thevillageschool.com

[†]These authors contributed equally

Abstract. In the modern society, scholars and researchers have already gained a fundamental understanding of our solar system, based on the multiple samples taken from a variety of detectors. Indeed, the detectors of planets in solar system play a vital role to investigate different planets. Therefore, with this in mind, this paper has compared with several state-of-art main-stream detectors, including Juno spacecraft, Akatsuki and Perseverance Mars Rover. According to the sample from Perseverance Mars Rover, scientists can make a progress in the understanding of Mars's composition and whether there is the scent of ancient life on Mars. In the accordance with Akatsuki's data, people have concluded the atmospheric structure on Venus. Based on the graphs gained by the Juno spacecraft, modern scientists can correct the theory of Jovian Lighting and understand the source of Zodiacal light. As a result, the thesis has concluded these three types of detectors 's characters, providing a relatively objective references about today's detector's features for the future development. Overall, these results shed light on guiding further exploration of planet detections.

Keywords: Detector; Mars; Venus; Jupiter.

1. Introduction

In October 4th of the 1957, Sputnik 1, the first probe to go into space, was launched by the former Soviet Union. The creation of sputnik 1 have five scientific objectives. After gaining the experience of launching space probes, more and more probes are created and launched into space, which includes Sputnik 2, Explorer 6, OSO-1 and more. Until now, space probes have various functions, also more durable and practical, which gives a lot more convinience for people who want to study the universe [1-3].

Some probes study Earth and create navigation systems by orbiting the planet. Some other probes are designed to travel a long distance to investigate other planets or asteroids or moons that are unfimiliar to us. They provided most of the imformation needed for people to study and observe the universe. Among various types of detectors, perseverance mars rover, juno spacecraft and Akatasuki have been achieved lots of impressing results [4-6]. During its first 100 days on Mars, Perseverance took more than 75,000 photos and sent them back to Earth. Its photo subjects include Martian landscapes, various interesting features, and of course, the Igenuity helicopter. Juno spacecraft is the second spacecraft to get to orbit jupiter. On September 29, 2022, NASA's Jupiter probe passed 352 kilometers above Jupiter's moon Europa, taking the closest photo for it in 20 years. Carrying six observation devices, Akatasuki will conduct a three-dimensional survey of Venus covered with thick clouds to explore the mechanism of a high-speed storm in the atmosphere of Venus with a speed of up to 100 meters per second.

In order to interpret the three detectors, this paper will explain the details about the three detectors. In this article, we will compare the three detector by analysing the specifics in each section. The reminder of the study will be organized and presented as follows. The Sec. 2 will explain detailed information about perseverance mars rover. The Sec. 3 will be talking about the goals and the

description of juno spacecraft. The Sec.4 will be about the discription and basic objectives of Akatasuki. Afterwards, the current shortcomings, defections and drawbacks of the detectors will be demonstrated in Sec. 5 and the future outlooks will also be presented for better develpomemt. Eventually, a conclude remark will be clarified in the last part of the article.

2. Perseverance Mars Rover

Launched in july 30 2020, the newest nasa`s mars rover has already made its way to mars after 7 month`s flying, landing in Jezero Crater, Mars on Feb. 18, 2021. Its main scientific goal is seek signs of the dirt and rocks on mars, waiting for opportunities to bring them back to Earth [7]. The mars rover is more than just a rover, the helicopter (named ingenuity) onboard is used to experiment whether flying with propellers is possible on mars. On April 19, 2021, Ingenuity completed its first flight on Mars, which is the first man controlled helicopter to fly outside Earth. The mars rover Perseverance is about 10 feet long , 9 feet wide ,7 feet tall and weighs about 2,260 pounds. The Rover Compute Element (RCE) ,brain of the rover is in the center of the main structure, which contains some functions for exchange of commands and science data collection. The mars rover is also equipped with a 7-foot-long robotic arm. Motors are located on the arm, allowing the arm to rotate in 5 directions. At the end of the arm is a drill to collect rock samples on the Mars surface [8-10]. A sketch of the detector is shown in Fig. 1. In summary, the mars rover Perseverance is an unprecedented detector, providing scientists with first-hand probe data to have a deeper insight into the planet.

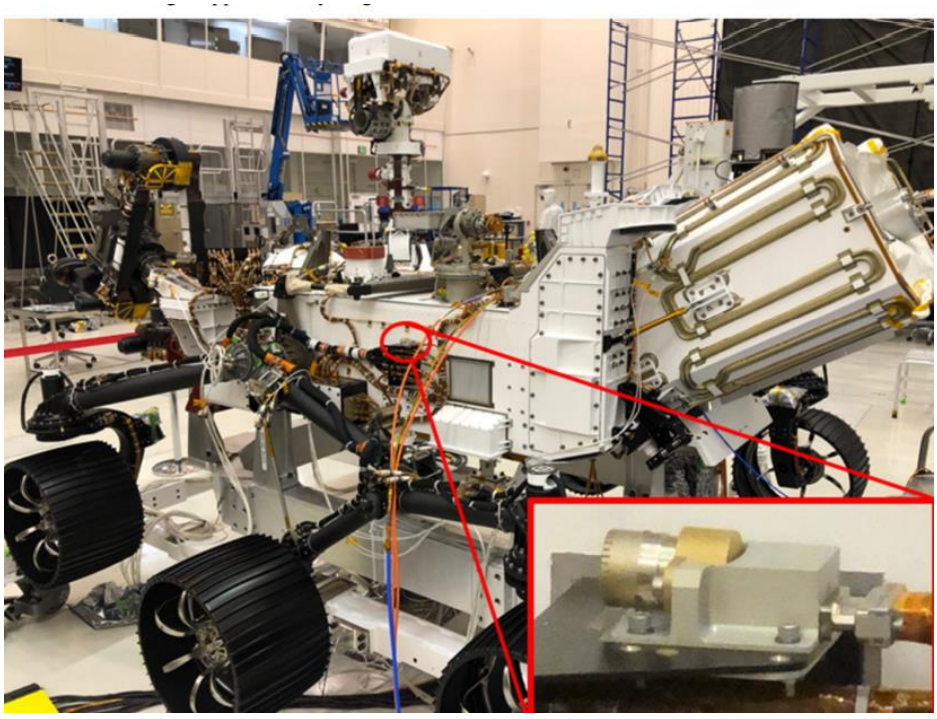


Fig. 1 A sketch of functions and components of Perseverance Mars Rover [4].

3. Juno Spacecraft

3.1. Description and Mission's Goals

Juno is a space probe built by NASA's Jet propulsion Lab, which is orbiting the planet of Jupiter. Juno is the second spacecraft orbiting Jupiter ever since the Galileo spacecraft ended its mission in 2003. Differ from the previous ones. Juno used three solar cell panels as the power source. After the mission, Juno was actively deorbited from Jupiter's atmosphere [11, 12]. Juno's goals including following:

- determine the ratio of oxygen to hydrogen;
- obtain a better estimate of Jupiter's core mass;
- precisely map Jupiter's gravitational as well as magnetic field.

3.2. Structure

The structure of it is illustrated in Fig. 2. Microwave radiometer includes six antennas intotal spreading in two sides of the body of the probe. Each of them measures the frequency of 600 MHz, 1.2, 2.4, 4.8, 9.6 and 22 GHz. Through combining different frequencies and measured angles, it is possible to collect the data of temperature at various levels of the atmosphere. JIRAM is basically a spectrometer mapper. By measuring the heat in different levels of the atmosphere, JIRAM is able to identify the tract of clouds and water movement beneath the surface. Magnetometer (MAG) is used to sketch the magnetic field. It is consisted of two parts, i.e., FGM and ASC. FGM functions as observing the strength and direction of the magnetic field while ASC monitor the orientation of FGM. Due to the uneven distribution of mass in Jupiter, the radio waves are used to demonstrate the mass distribution inside of the planet. Similar to the JADE, Jovian Energetic Particle Detector Instrument (JEDI) practices the same theory on the spacecraft. The electron analyzers are placed on three sides of the upper plate. This increases the efficiency to 3 times. Ultraviolet Spectrograph provides the diagram of the UC emissions on the polar magnetosphere. JunoCam (JCM) is A visible light camera that helps to facilitate education and public outreach.

3.3. Scientific Conclusion

With the early data collected, Juno correct the theory of Jovian Lighting. Jono provides the first view of the north pole of Jupiter. By analyzing the frequency of the interplanetary dust impact, Juno found the cause of Zodiacal light is not the comets or asteroids. Instead of that, it comes from this dust [14].

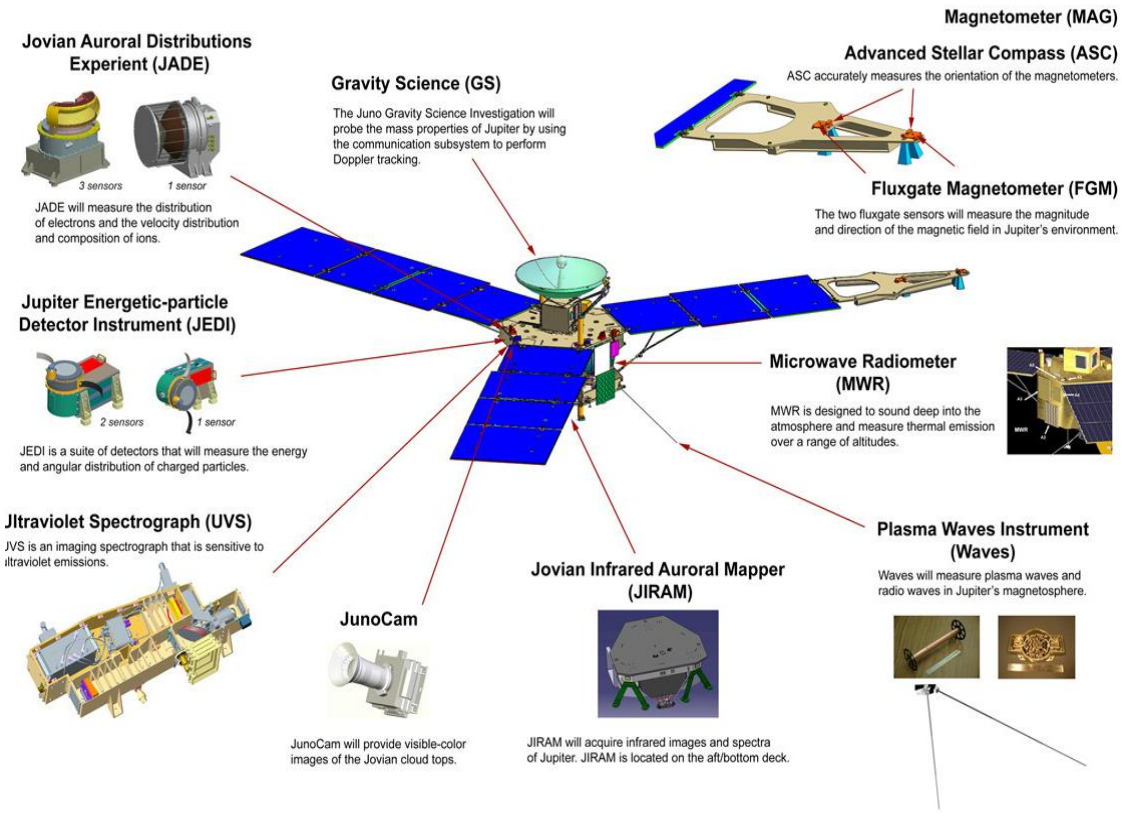


Fig. 2 A sketch of functions and components of Juno [13].

4. Akatasuki

4.1. Descriptions & Main Objective

Akatasuki is a type of Venus orbiter emitted by the JAXA. As Japan's first planetary exploration mission. Its launch mass reaches 517.6 kg and dry mass has 320 kg. The dimensions of it is 1.04 m × 1.45 m × 1.44 m. The power of Akatsuki would be larger than 700 watts at 0.7. The budget for the satellite reach US$174 million and US$116 million for the launch [6]. The major mission of it is to explore the Venus. By using 5 camera at different wavelength to learn the stratification of the atmosphere. In addition, there are other experiments.

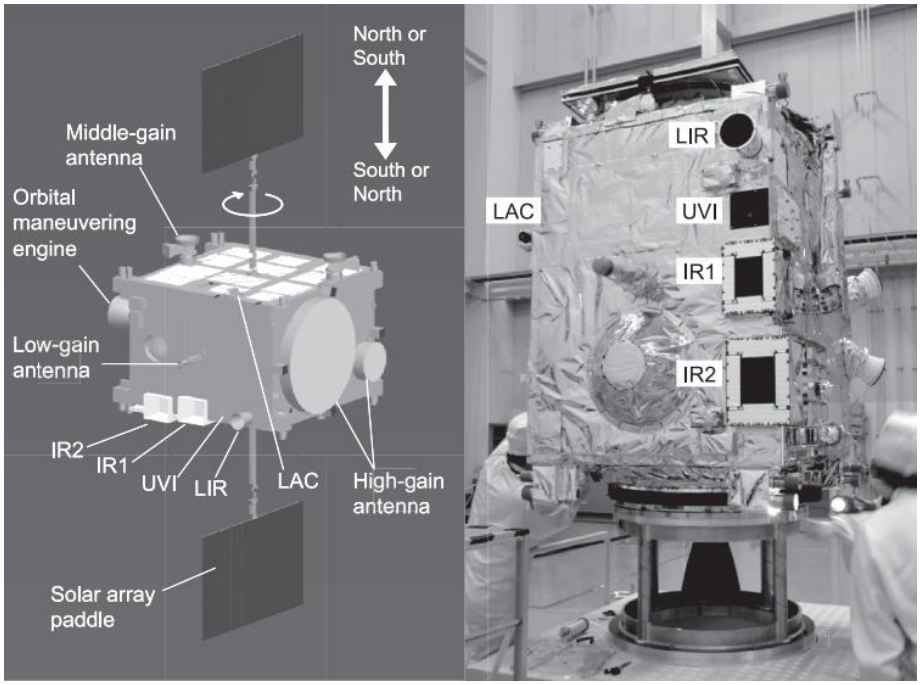


Fig. 3 A sketch of Akatasuki [6].

4.2. Structure

The main bus is a 1.45 × 1.04 × 1.44 m box with two solar arrays in Fig. 3. Two solar arrays ' area reach 1.4 m^2 which are able to provide over 700 W of power in Venus orbit. As the first spacecraft that exploit a ceramic retrofire thruster, the total propellant mass at launch was 196.3kg. Communication system depends on an 8 GHz, 20-watt X-band transponder using the 1.6 m (5 ft 3 in) high-gain antenna. In addition, in order to achieve housekeeping data downlink when the high-gain antenna is not facing Earth, Akatsuki was equipped with a pair of medium-gain hon antennas. The number of instruments on Akatsuki have six, and five of them are imaging cameras as follows:

- The Lightning and Airglow Camera (LAC), which can be used to detect spectra of visible wavelength.
- The ultraviolet imager (UVI), which is able to explore the distribution of specific atmospheric for UV light.
- The longwave infrared camera (LIR), which can be utilized to detect EM waves with larger 10 μm wavelength.
- The infrared 1 μm camera (IR1), which would image heat radiation emitted in the daytime while reflections in other cases.
- The infrared 2 μm camera (IR2), which would capture infrared rays emitted from the atmosphere below the cloud layer and leaking into outer space to observe the distribution and movement of clouds and carbon monoxide. We will also observe the zodiacal light (planet > dust) between the time we left Earth and arrived at Venus.

- The Ultra-Stable Oscillator (USO), which is installed in order to perform radio occultation experiments

5. Conclusion

In summary, this paper discusses today's mainstream detectors based on structures and scientific goals. Specifically, Juno spacecraft, Akatsuki and Perseverance Mars Rover are demonstrated and compared. According to the analysis, the Akatsuki orbiter revealed climate situations on the Venus like the Venus atmosphere structure. In addition, Juno corrected the theory of Jovian Lighting and found that the Zodiacal light is caused from the interplanetary dust impact. Besides, as a new detector equipped with cutting-edge technology instruments, Perseverance Mars Rover collected the sample of gases on the Mars which would be really useful for the future. Nevertheless, these detectors still have some limitations. For example, the protection and maintenance of the instrument is not well enough like now the IR2 in Akatsuki disconnected; the most of detectors still have very large cost. In the future, scientists can collect the reasons of these disconnection and make the corresponding improvements, so each detector would be more sustainable and cost-efficient; scientists can develop some potential and less-expensive materials for the detector. Overall, these results offer basic guild line for future detectors' development.

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