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Progress of microgravity experimental satellite sj-10

Abstract

The program SJ-10 is one of the scientific satellite programs in the Strategic Priority Research Program on Space Science, the Chinese Academy of Sciences, and was launched in April 6, 2016. There are totally 19 scientific payloads with a payload of multi-function furnace for 8 materials research missions and a payload of three-dimensional cell culture for the neural stem cell mission and the hematopoietic stem cell mission respectively etc. (WR Hu et al.).[1] The recoverable satellite consists mainly of two capsules: a recoverable capsule had been recovered at April 18, 2016 with all payloads of life science in addition of the payload of the multi-function furnace and the payload for measurements of Soret coefficients of crude oil (SCCO), and an un-recoverable capsule had persisted to work in additional 8 days of all other physical payloads. The experiments were operated via tele-operations, and all experimental data were received by 3 ground stations. The data and recoverable samples have been analyzed by the teams of experimental program.

Keywords: scientific satellite, SJ-10, microgravity science, space life science, recoverable satellite

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Introduction

Microgravity experiments for long period, which could be performed only in the space orbit vehicle such as space station, space shuttle, and satellite, are essential for the development of microgravity science and space life science. The recoverable satellite is a useful and efficient tool for space experiments in the microgravity environment,[2,3] and such kind of satellites have been launched successfully 23times in China (Li et al.).[3] Space microgravity experiments in China have been completed mainly aboard the recoverable satellites since the late 1980's[4] and the spaceships Shenzhou since the late 1990's. The launch of the satellite SJ-8 was a turn point of transportation the mission purpose from earth observation mainly to microgravity experiments. The main scientific results of SJ-8 missions were published in a special issue of Microgravity Science and Technology.[2] The space experiments of microgravity fluid physics, including one in cooperation with the Russian scientists aboard the Mir space station, were summarized by Hu et al.[5] The program of SJ-10 satellite was organized by the Chinese National Space Administration (CNSA) in the middle of 2000's. 10 experiments of microgravity science and 10 experiments of space life science were selected from more than 200 applications of SJ-10 mission in the early of 2005. The mission proposal of space experiments was reviewed in the October of 2005. The engineering proposal of satellite platform was reviewed in May of 2006 by the CNSA. Then, the demonstration working group on "recoverable satellite of scientific experiments for space environment utilization" was formally organized, and the mission was determined as SJ-10. Unfortunately, the demonstrative phase was stopped after one year due to the reform of CNSA, and re-started when the government of China determined to move the national management of scientific satellite from CNSA to the Chinese Academy of Sciences (CAS) in 2011. The re-started demonstration phase was completed in the end of 2012, and the engineering phase of program SJ-10 was started since the beginning of 2013. Then, the satellite was launched at April 6, 2016. In the SJ-10 program, there are 6 experiments in the field of microgravity fluid physics, 3 in microgravity combustion, 8 in space material science, 3 in radiation biology, 3 in gravitational biology, and 4 in space biotechnology. Main scientific purposes of these experiments may be summarized as follows.

a. To promote the basic research of fluid physics and biology experiments;

b. To support the manned space flight for fire safety research;

c. To improve the human health by biotechnology studies;

d. To develop the high-technology by experiments of coal combustion, materials processing and biotechnology.

The issues of selected space experiments are listed respectively in Table 1 for microgravity science and Table 2 for space life science.

The recoverable satellite is a very useful spacecraft for microgravity experiments and the satellite of SJ-10 is the 25th recoverable satellite of China. The structure of SJ-10 satellite is shown in Figure1. The SJ-10 satellite is flight in a circle orbit, and its main parameters are given as follows (Table 3).

The residual gravity acceleration is shown in Figure 2 for 2500s after 3days of launch. And the pressure change in unrecovered capsule is shown in Figure 3 for 18days.

Flight experimental phase was in the period April 6, 2016 to April 25, 2016, and the operation was successful as

a. The flight was in the designed orbit;

b. The perform the space science experiment was operated in order, and transferred the scientific data to the ground station;

c. Analyze the scientific data of space experiments online in the command and control center of science application system;

d. Analyze the scientific results from the recoverable facilities in laboratory.

Table 1 List of microgravity science experiments

S.no	Title	Institution	PI
1	A1-1. Microgravity A1-1 Space experiment of evaporation and Fluid physics fluid interfacial effects.	Inst. Mech., CAS	Q.S. Liu
2	A1-2. Phase separation and dynamic clustering in granular gas.	Inst. Phys., CAS	M.Y. Hou
3	A1-3. Thermal dynamical behavior of vapor bubble during pool boiling.	Inst. Mech., CAS	J.F. Zhao
4	A1-4. Space experimental on surface wave of thermocapillary convection.	Inst. Mech., CAS	Q. Kang
5	A1-5. Study on the colloidal assembling.	Inst. Mech., CAS	Y.R. Wang
6	A1-6. Soret coefficients of crude oil (SCCO).	ESA,Inst. Mech., CAS	A. Verga and Z.W. Sun
7	A2-1. Combustion on ignition, soot emission and smoke distribution of wire insulations by overload.	Eng. Inst. Thermophys., CAS	W.J. Kong
8	A2-2/3. Investigation of the coal combustion and pollutant formation characteristics under microgravity.	Tsinghua Univ. Huazhong Sci. & Tech. Univ.	H. Zhang and M.H. Xu
9	A2-4. Ignition and burning of solid materials in microgravity.	Inst. Mech., CAS	S.F. Wang
10	A3. Solidification and crystal growth in space.	Inst. Semiconductor, CSA, et al	X.W. Zhang et al.

Table 2 List of space life science experiments

S.no	Title	Institution	PI
1	B1-1. Molecular biology mechanism of space radiation mutagenesis	Dalian Maritime Univ	Y.Q. Sun
2	B1-2. Roles of space radiation on genomic DNA and its genetic effects	Inst. Biophysics, CAS	H.Y. Hang
3	B1-3 Effects of space environment on silkworm embryo development and mechanism of mutation & Ecology	Inst. Plant Physiology, CAS	Y.P. Huang
4	B2-1. Biological effects and the signal transduction of microgravity stimulation in plants	Inst. Plant Physiology, CAS	W.M. Cai
5	B2-2. Biomechanics of mass transport of cell interactions under microgravity	Inst. Mech., CAS	M. Long
6	B2-3. Photoperiod-controlling flowering of Arabidopsis and rice in microgravity	Inst. Plant Physiology & Ecology, CAS	H.Q. Zheng
7	B3-1. Three-dimensional cell culture of neural stem cells in space	Inst. Genetics & Developmental Biology, CA	J.W. Dai
8	B3-2. Three-dimensional cell culture of hematopoietic stem cells in space	Inst. Zoology, CAS	Y. Zhao
9	B3-3. Development of mouse early embryos in space	Inst. Zoology, CAS	E.Q. Duan
10	B3-4. Potential and molecular mechanism of osteogenic differentiation from human bone mesenchymal stem cells	Zhejiang Univ	J.F. Wang

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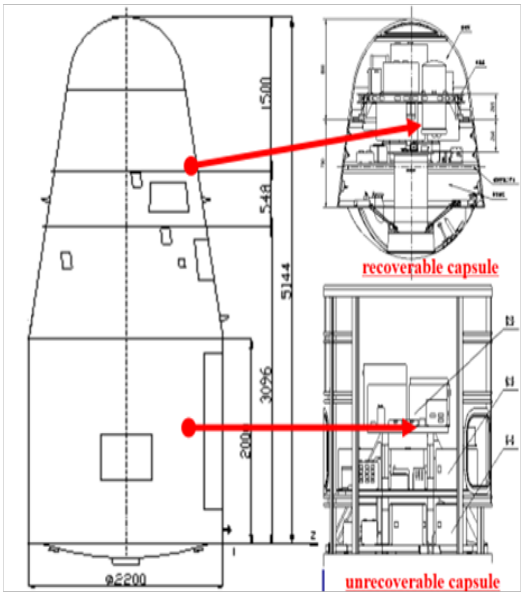

Figure 1 Schematics of SJ-10 satellite, the satellite structure is in left part, and recoverable capsule and un-recoverable capsule are shown respectively in the right upper and right lower part.

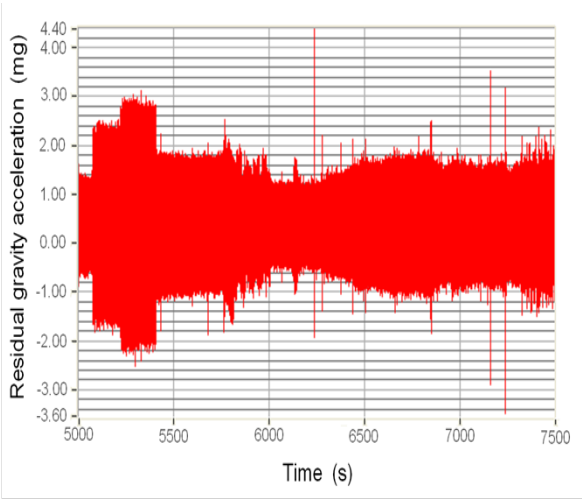

Figure 2 Residual gravity acceleration.

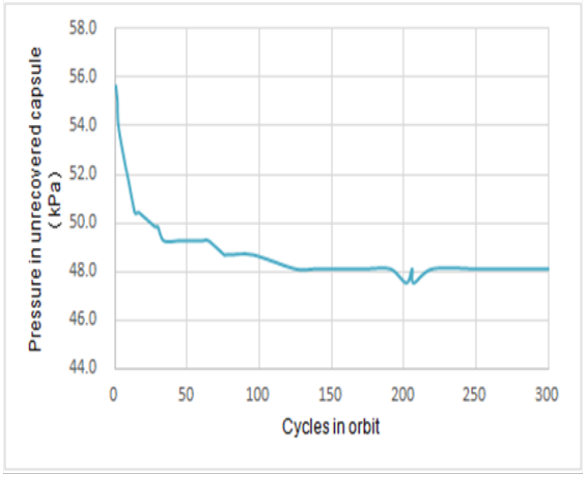

Figure 3 Profile of the pressure in unrecovered capsule.

Table 3 Properties of SJ-10 satellite

1	Total mass	≤3600kg
2	Orbital Inclination	43°
3	Orbital altitude	~ 255 km
4	Life span	12 + 8 days
5	Gravitation level	Better than 10^{-3}g
6	Payload	• 270kg (recovery capsule) • 280kg (unrecovered capsule)
7	Rocket	CZ-2D
8	Launch date	6-Apr-16

Conclusion

The method of tele-science was used during the space experimental period. The space experiments were operated by the command control center of science application system, and the PIs can adjust the experimental parameters during the experimental period. The recoverable satellite is the useful infrastructure for microgravity science and space life science, and the missions of microgravity experimental satellite SJ-10 were very successful.

Acknowledgments

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Conflict of interest

Author declares that there is no conflict of interest.

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