Tenure Review

Peking University

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School: School of Earth and Space Sciences
Profession: Planetary Remote Sensing
Position: Assistant Professor

October 1, 2016
Personal Statement for Tenure Review

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I received my Ph.D. degree (supervisor: Prof. Ya-Qiu Jin) in microwave remote sensing from Fudan University in Jan. 2009. From Feb. 2009 to May 2011, I was as a postdoctoral fellow (supervisor: Prof. Mark A. Wieczorek) at Institut de Physique du Globe de Paris. In June 2011, I returned back to China and joined the School of Earth and Space Sciences at Peking University as an assistant professor, with an ambition to promote China’s planetary sciences. I really enjoy my current position and have integrated myself with our school and university. This is an inspiring and productive period in my career, and a challenging, but happy, time in my life. My research, teaching, and service achievements are summarized as below.

Research
- Received 2.67 million RMB funding, including three grants from National Natural Science Foundation of China (NFSC).
- Published 14 academic papers since Aug. 2011 (25 papers since 2007).
- Established widely international collaborations.
- Received the Second Class State Natural Science Award in 2011.

Teaching
- Taught two graduate courses, and co-taught two courses with two other professors.
- Supervised/supervising three Ph.D. students, one master student, three undergraduate students, one visiting student, and one high school student.
- Received Outstanding Teaching Award of Peking University in 2014.

Services
- Regular reviewer for >10 peer-reviewed journals, foundations, dissertations, and faculty promotion.
- Committee member of two international conferences and three domestic workshops.

It is my honor to work and live at Peking University. I deeply benefit from the mutual promotion among various scientific subjects in our school and university. I hope to continue my research and teaching in such a prestigious university, and therefore, submit my application for the tenure position.

October 1, 2016
**1. Research**

*Overview:* Recently, with a renewed interest in planetary exploration, a variety of microwave remote sensing instruments, with different techniques, frequencies, and polarizations, have been used to study the Moon, Mars, Mercury, Venus, and asteroids. These include Earth-based radar, synthetic aperture radar, sounding radar, ground penetrating radar, and microwave radiometer. Microwave signals can penetrate loose sediments such as dust, regolith, and alluvium to provide a view about a planet’s subsurface geologic structure that is complementary to observations in the visible, infrared, and thermal infrared regimes.

My research interests lie generally in planetary microwave remote sensing, and focus primarily on three topics: (1) planetary radar remote sensing, (2) radiometric remote sensing of the Moon, and (3) planetary surface properties. During the past 10 years, I have completed a series of foundational works for microwave remote sensing of the Moon, including forward modeling, numerical simulation, data validation, and geophysical parameter inversion. Most of these models are based on electromagnetic (EM) wave propagation principles, and hence can take into account the complex interactions of EM waves with the lunar surface. By analyzing radar and radiometer data using these models, information can be acquired about the lunar surface and subsurface that is inaccessible from analyses of other datasets. In order to reduce ambiguity in microwave data interpretation, I also study planetary surface properties using other datasets and methods. Currently, most of my work focuses on the Moon, but I am also interested in Mercury, Mars, and the asteroids.

I have published 25 papers in peer-reviewed journals in total, among which 15 were the first/corresponding author, with 211 citations (Web of Science). More than 10 of these papers appear in *Geophysical Research Letters*, *Journal of Geophysical Research-Planets*, and *Icarus*. During the past five years of my tenure track, I have published 14 papers, among which 8 were the first/corresponding author. I also received 13 research grants, including 3 NSFC grants. For details of my publications and grants, please see my CV.

**1.1 Radar Remote Sensing of the Moon**

Radar is a powerful tool in lunar exploration in that it can be used to characterize the topography, geology, and subsurface structure of the Moon (e.g., *Campbell*, 2002). One particular interest is to use the radar circular polarization ratio (CPR) to search for potential water ice in permanently shaded regions (PSRs) near the Moon’s poles (e.g., *Nozette et al.*, 1997; *Stacy et al.*, 1997). Previously, I have developed a quantitative radar scattering model for the lunar regolith layer using vector radiative transfer theory (*Fa et al.*, 2011), and an
effective simulation approach for sounding radar echoes from the deep lunar subsurface (Fa and Jin, 2010). My recent radar remote sensing works focus mainly on NASA’s miniature radio frequency (Mini-RF) synthetic aperture radar and China’s Chang’E-3 lunar penetrating radar (LPR).

a. **Mini-RF data analysis for water ice detection**

Potential water ice within the Moon’s PSRs is not only regarded as one of the most valuable resources in the solar system, but also contains critical information concerning significant questions about the Moon and the solar system. The recent Mini-RF radars found a class of anomalous craters with high CPR only interior region to their rims, but not exterior to their rims (Spudis et al., 2010). Most of these craters are located in PSRs, and were therefore interpreted as potential sites for water ice deposits (Spudis et al., 2010, 2013).

In our study, we investigated >70 impact craters across the Moon using Mini-RF data, and analyzed the influences of surface slope, rocks, roughness, and dielectric constant on the enhanced CPRs within anomalous craters (Fa and Cai, 2013). We found that there is a strong correlation between radar CPR and surface rocks. We developed a two-component radar scattering model (Fig. 1a), and its predictions match well with the observed CPRs and the counted rock abundances (Fig. 1b). We concluded that the enhanced CPR in the interior of anomalous craters is most probably caused by rocks that are perched on the lunar surface or buried in regolith, instead of ice deposits as suggested by the Mini-RF team. A later observation by the LRO narrow angle cameras revealed abundant surface rocks over PSR craters (Kober et al., 2014), which supports our conclusion.

![Figure 1](image-url) (a) A two-component mixed radar scattering model, (b) CPR as a function of rock abundance (fs) (Fa and Cai, 2013).

I am currently analyzing the global Mini-RF image with Dr. Vincent Eke at Durham University. We made a global Mini-RF mosaic, searched all the anomalous craters, and studied the relation between CPR and rock abundance. Our preliminary results show that there is no apparent difference in CPR characteristics between the polar and nonpolar anomalous craters. What Mini-RF observed is probably subsurface rocks, and this can help
us better understand the evolution of impact craters. We plan to submit the results to *Journal of Geophysical Research-Planets* in two months.

**b. LPR data analysis for lunar subsurface structure**

In China’s Chang’E-3 (CE-3) lunar mission, a rover deployed ground penetrating radar (called the LPR), for the first time, is used to characterize near surface geology, subsurface structure, and the dielectric properties of the Moon. I first analyzed key factors (e.g., frequency, range resolution, and antenna directivity) that could affect a lunar GPR performance, and simulated GPR echoes and radargrams over the Sinus Iridum region (*Fa*, 2013). Then, I processed the CE-3 LPR raw data at 500 MHz and investigated regolith stratigraphy at the landing site (Fig. 2a). The processed LPR images reveal four major stratigraphic zones: a layered reworked zone (<1 m), an ejecta layer (~2–6 m), a paleoregolith layer (~4–11 m), and the underlying mare basalts (Fig. 2b). Using surface age, we further found that the mean regolith accumulation rate is about 5–10 m/Gyr at the landing site, which is at least 4–8 times larger than previous estimations (*Fa et al.*, 2015).

![Figure 2](image.png)

**Figure 2.** (a) The processed LPR images at 500 MHz, (b) Subsurface structure at the CE-3 landing site (*Fa et al.*, 2015).

I further developed a method to invert dielectric permittivity and bulk density of lunar regolith using the hyperbolic curves in the LPR images. I investigated the relations between the eccentricity of the hyperbola, dielectric constant, bulk density, and depth of buried rocks using geometrical optics. Then, I estimated the dielectric permittivity and bulk density of regolith at the CE-3 landing site. The results show that the dielectric permittivity of the regolith varies from 1.1 to 6.1, and that the regolith bulk density increases with depth from 0.86 g/cm³ at the surface to a steady-state value of 2.27 g/cm³ at 5 m (*Fa*, 2016). This can help us to understand lunar subsurface property at a depth that was not reached by Apollo probes.

**1.2 Radiometric Remote Sensing of the Moon**

The thermal behavior of the lunar surface is an important indicator of its physical properties, such as grain size, bulk density, porosity, thermal conductivity, rock abundance, and internal heat flow (e.g., *Hale and Hapke*, 2002). Radiometric remote sensing of the Moon at infrared and microwave bands can give us a wealth of information about its thermal properties (e.g.,
Urquhart and Jakosky, 1997). My recent works on radiometric remote sensing focus on the thermal conductivity and temperature profile of lunar regolith, and “cold spot” craters from Diviner and Chang'E-1/2 radiometer observations.

a. Thermal Conductivity of Lunar Regolith from Diviner Radiometer Data
The thermal conductivity of lunar regolith is composed of solid conductivity and radiative conductivity. We resolved the one-dimensional heat transfer equation, and obtained diurnal surface temperature. We analyzed surface temperature variation during lunar nighttime as functions of solid conductivity, bulk density, albedo, emissivity, and rock abundance. Then, using Diviner bolometric temperature and the least-squares method, we estimated solid conductivity of lunar regolith for regions between 60°N and 60°S (Fig. 3). The results show that solid thermal conductivity of surficial lunar regolith varies generally from 0.0001 to 0.0300 W/mK. We also found that solid conductivities for young fresh impact craters are extremely high, and that there is a strong correlation between solid thermal conductivity and absolute ages for these young craters (Yu and Fa, 2016).

![Figure 3. The estimated solid conductivity of lunar regolith (Yu and Fa, 2016).](image)

b. Thermal Properties of Lunar Regolith Chang'E Microwave Radiometer Data
For Chang'E-2 microwave radiometer data analysis, we first constructed a global microwave brightness temperature (TB) map at noon and midnight (Fig. 4), and discussed their global distribution characteristics. We analyzed factors affecting high-frequency TB, such as surface slope, solar albedo, and dielectric constant. We then developed a thermal emission model for a semi-infinite regolith medium based on radiative transfer theory, which considers dielectric constant and temperature profiles of the regolith. Finally, we inverted mean diurnal surface and subsurface physical temperatures using diurnal averaged TBs at 19.35 and 37 GHz. Our results show that latitude variations of the mean diurnal surface and subsurface temperatures follow simple rules as $\cos^{0.3} \varphi$ and $\cos^{0.36} \varphi$, respectively. The inverted temperatures at the Apollo 15 and 17 landing sites are also compared with the
Apollo heat flow experiment data, showing an estimation uncertainty <4 K for surface temperature and <1 K for subsurface temperature (Fang and Fa, 2014).

In CE-1/2 microwave TB images, we found a class of young fresh craters (cold spot craters), where their TBs at nighttime are much lower than the surrounding regions. In contrast, in the Diviner infrared TB image, TBs of these craters are higher than their background regions. In total, we identified 313 cold spot craters in CE-2 microwave images using a flow direction algorithm. We found that TBs of cold spot craters are ~9 K lower than their background regions, and that the density of cold spot craters decreases with latitude. In high-resolution optical images, we found that there are abundant meter-scale surface rocks in the cold spot region, and that almost no rocks occur in their background region. We proposed a rock-regolith mixture model for the cold spot region, and then combined the one-dimensional heat transfer equation and microwave radiative transfer model for physical temperature and TB modeling. The results suggest that rocks in the crater interior and continuous ejecta can significantly increase the thermal inertia of the regolith while reducing the temperature gradient and heat transfer efficiency. As a result, surface temperatures over cold spot regions are higher whereas subsurface temperatures are lower, which can explain the different behaviors of cold spot craters at microwave and infrared bands. The thermal behavior, distribution characteristic, and formation mechanism of cold spot craters can help us to understand the emplacement of the materials during an impact cratering event and later modification of the ejecta (Wang et al., 2016).

Figure 4. Distribution of cold spot craters in 37 GHz TB map (Wang et al., 2016).

1.3 Planetary Surface Properties
The surface properties of a planet reflect its current state and provides key information about its formation and evolution. I also study lunar surface properties (e.g., slope, roughness, regolith thickness, and dielectric permittivity) using other remote sensing and geophysical data. This can help to reduce ambiguities in microwave data interpretations, and also help to cross-validate inversion results from microwave data. Most of my current work focuses on the Moon, but I intend to extend all these techniques to other planets and asteroids.
a. Regolith Thickness from Morphology of Small Fresh Impact Craters
High-resolution optical images from recent lunar missions provide an opportunity for estimation of the lunar regolith thickness using morphology and the size-frequency distribution of small impact craters. We revised the relationship between crater geometry and regolith thickness based on previous experimental data (Quaide and Oberbeck, 1968). We further summarized the rules for regolith thickness estimation using crater morphology, including lunar surface geologic unit division, optical image selection, crater morphology identification, and regolith thickness calculation (Liu et al., 2015). Using LROC images, we estimated regolith thickness at the Apollo landing sites, and compared the results with Apollo in situ measurements. We applied these rules to the Sinus Iridum region and the CE-3 landing site. Results show that 50% of the Sinus Iridum region has a regolith thickness between 5.1 and 10.7 m, and the mean thickness is 8.5 m (Fa et al., 2014). At the CE-3 landing site, the median regolith thickness is estimated to be 8 m, which is comparable with the LPR observations (Fa et al., 2015). Using the recent high-resolution optical images and our refined rules, the lunar regolith thickness over large regions can be estimated with a better precision, which can help us to understand the formation and evolution of the lunar surface. This work is published in JGR-Planets, and is selected as a featured article.

b. Topographic Roughness of Mercury from MESSENGER Laser Altimeter
As a quantitative measure of topographic relief, topographic roughness is directly related to geologic evolution of a planet’s surface. We investigated surface roughness for the northern hemisphere of Mercury using MESSENGER laser altimeter data (Fa et al., 2016). Our results show that there are distinct differences in the bidirectional slope and root mean square (RMS) height among smooth plains (SP), intercrater plains (ICP), and heavily cratered terrain (HCT). For these three geologic units, the ratios of both the bidirectional slope and RMS height among the three geologic units are both about 1:2:2.4 (SP:ICP:HCT). Most of Mercury’s surface exhibits fractal-like behavior, with median Hurst exponents of 0.66, 0.80, and 0.81 for SP, ICP, and HCT, respectively (Fig. 1b). The median differential slope map shows that smooth plains are smooth at kilometer scales and become rough at hectometer scales, but they are always rougher than lunar maria. In contrast, intercrater plains and heavily cratered terrain are rough at kilometer scales and smooth at hectometer scales, and they are rougher than lunar highlands at scales <2 km, but smoother at >2 km (Fig. 1c). We suggest that the scale-dependent roughness characteristics between Mercury and the Moon are mainly caused by the differences in density and the geometry of impact craters.
Figure 5. (a) topography, (b) Hurst exponent, and (c) Composite color map of the median differential slope for the northern hemisphere of Mercury (Fa et al., 2016).

c. Properties of Toutatis from Chang’E-2 Fly-by Observations

On 13 December 2012, the Chang’E-2 spacecraft conducted a flyby observation of the asteroid (4179) Toutatis. The high-resolution optical images and radio tracking data provided a chance to study the mysteries of Toutatis. In a collaboration with Dr. Yanlong Bu, we constrained the dimension (4354 m × 1835 m × 2216 m) of Toutatis and its spatial orientation at the time of imaging, based on the photogrammetric relation between the CE-2 spacecraft and Toutatis (Bu et al., 2015). We further estimated the relative trajectory between CE-2 and Toutatis using dynamics, optical, and radio constraint data and a strict photogrammetric model (Bu et al., 2016).

In another collaboration with Dr. Meng-Hua Zhu, we studied the morphology (e.g., impact craters, boulders, grooves) of Toutatis using high-resolution optical images (Zhu et al., 2014). We identified more than 70 impact craters with diameters from tens of meters up to 800 m, and found that most craters are degraded by surface resetting. The less degraded large crater with a diameter of ~800 m at the south pole is estimated to be produced by an impactor with a diameter of ~50 m from strength crater scaling relations. From the analysis of large-impact events on highly porous targets, we argued that Toutatis is likely a rubble-pile body and its two lobes are contact binaries. This work is published in GRL, and is selected as Editors’ Choice by Science.

References


2. **Teaching & Student Supervising**

2.1 **Teaching**

I teach two graduate courses: *Planetary Remote Sensing* and *Academic Writing for Graduate Students*, each with 32 credit hours. On average, the teaching evaluation score by students of *Academic Writing for Graduate Students* is 95.38 out of 100, respectively. Each of these courses is supported by a teaching grant from Peking University. I also co-teach two courses: *Microwave Remote Sensing* with Prof. Qiming Zeng (8 credit hours for me), and *Seminars on Remote Sensing and Mapping* with Prof. Lei Yan (16 credit hours for me). I received Outstanding Teaching Award from Peking University in 2014.

**Planetary Remote Sensing**: The aim of this course is to provide students extensive knowledge of planetary remote sensing techniques and introduce several intensive cases on how to resolve a scientific problem using multiple datasets and methods. The course begins with an introduction to the solar system and planetary properties, with the Moon as a detailed case study. As the main part, basic principles and scientific applications for most remote sensing techniques in planetary explorations, including laser altimetry, optical camera, reflectance spectroscopy, radar remote sensing, infrared and microwave radiometry, and nuclear planetology (X-ray, Gamma-ray, and neutron spectroscopy) will be introduced. Then, the planetary data system (PDS) and software in PDS data processing are introduced, followed by a two-hour practice on computers. The last section will introduce two in-depth cases on how to resolve a complex scientific problem using multiple remote sensing techniques.

**Academic Writing for Graduate Students**: The purpose of this course is to introduce graduate students to the basic skills of scientific writing and the ethics of scientific publishing. The course begins with an introduction to the basic flow chart of scientific research and academic writing. The format and structure of a scientific paper is first introduced, followed by skills on how to find and read a paper (e.g., the famous *three-pass method*) and how to do a literature survey of a new field. As the main part, the course provides information on how to prepare each section of a scientific paper, covering the title, authorship, abstract, keyword, introduction, material and method, result, discussion,
conclusion, acknowledgements, and references. Next, guidance on the design of figures (using Matlab, origin, Microsoft Visio, Generic Mapping Tools) and tables and editing assignments are introduced, followed by a two-hour computer practice. Also, tips on scientific journal selection, online submission system, communication with the editor, and the peer review system are presented. Especially, academic ethics in scientific research and academic writing are introduced with extensive cases. Finally, skill on how to make a presentation and a poster for an international conference, how to write a CV, how to find a Ph.D. or postdoc position, and how to write a research proposal will be introduced.

**Microwave Remote Sensing:** I introduce the basic theory of electromagnetic scattering and fundamentals of random scattering, then mainly focus on the radiative transfer theory, including the equation and its component, solution techniques, and its applications in active and passive microwave remote sensing.

**Seminars on Remote Sensing and Mapping:** I invite top scientists in remote sensing and photogrammetry in China to give lectures for first-year Ph.D. students, and I also organized a discussion after each lecture. Such frontier lectures can bring the latest progress in remote sensing to our students, and also broaden their knowledge and insight.

### 2.2 Student Supervising

I supervised one master student and three undergraduate students, and I hosted one visiting graduate student and one high school student. Currently, I am supervising three Ph.D. students, and one of them will graduate in July 2017. We have a group meeting every Tuesday, and additionally I discuss with each student every two weeks on average. Here are some highlights for my students:

- Ph.D. students Jun Du and Yuzhen Cai received President Scholarship of Peking University (the best scholarship in Peking University).
- Ph.D. student Jun Du received an exchange scholarship from China Scholarship Council, and will go to France for a co-thesis study of 18 months.
- Master student Tiantian Liu received the National Scholarship for Graduate in 2014 (the only one in our school at her grade), and is now a Ph.D. student in Technische Universität Berlin, Germany.
- Two undergraduates, Yuanzheng Xiao and Yingjie Wang, each received an undergraduate research grant from our university.
- Undergraduate student Tuo Fang published a paper in *Icarus* as the first author.
- The students gave 3 oral and 6 poster presentations in international conferences, including 1 oral and 4 poster presentations in lunar and planetary science conferences.
- All the three undergraduate students are now pursuing their master/Ph.D. degrees
abroad: Yuanzheng Xiao (Ph.D. student, University of Hawaii), Tuo Fang (master student, University College London), and Yingjie Wang (master student, École des mines de Nantes).

3. Services

3.1 Serving School & University

I served as a member of the working teams to prepare the external evaluation of SESS (School of Earth and Space Sciences) in 2015, and discipline evaluation by the ministry of education in 2016. I was in charge of the part related to remote sensing and geographical information systems, which included the overall performances in education, research, cooperation and exchange, public services, update of other information like the alumni situation, and report writing.

Since March 2016, I have served as a member of the planning team of SESS, assisting the dean to make plans for disciplines and human resources in SESS, especially assisting SESS to promote planetary sciences in our university.

In the past five years, I invited more than 20 international and domestic planetary scientists to give seminars in our university, in order to promote planetary sciences here. Since September 2015, I have organized the monthly Planetary Science Lunch Meeting in our university. I contacted all the academic staffs in planetary sciences in our university (including >15 academic professors from atmosphere, geology, geophysics, space physics, and remote sensing), and then organized the monthly lunch meetings.

In June 2015, I served as a member of the panel interviewing for Boya Plan of Talents Training in Peking University. Together with two other professors, I interviewed 59 high school students. Since October 2015, I have served as a member of the academic ethics education group in the graduate school, discussing how to teach academic ethics for graduate students in our university, and helping prepare teaching cases in academic ethics education.

3.2 Serving Society

Currently, I serve as an associate editor for Journal of Geophysical Research: Planets, and I help the editor-in-chief to oversee manuscripts about planetary radar.

As a proposal reviewer, I have reviewed >20 research project proposals submitted to the National Natural Science Foundation of China (NSFC). I am also a regular reviewer for Ph.D. dissertations for the Ministry of Education Degree Center, and I have reviewed >10 dissertations since 2014.

Since 2012, I served as a committee member for two international workshops (the Second International Symposium on Lunar and Planetary Science, and the Second International Workshop on Earth Observation and Remote Sensing Applications), and a committee member for three domestic conferences.
Future Plans

1. Research
In the next several years, I will continue working on planetary microwave remote sensing, and especially I will dedicate to resolve several fundamental problems.

1.1 Planetary Radar Remote Sensing
I will improve my previous lunar radar scattering model to include large buried rocks, multiple scattering between rocks, and the coherent backscatter opposition effect (CBOE). I will use numerical approaches (e.g., Method of Moments, Finite-Difference Time-Domain) to calculate the scattering matrix of large rocks, an iterative method to resolve the radiative transfer equation to consider multiple scattering, and analytical wave theory to study CBOE.

By applying the improved radar scattering model to recent radar data, I will quantify lunar surface roughness, the size and abundance of subsurface rocks, and the thickness and dielectric properties of the regolith. From these properties, important geological questions about the Moon, such as the evolution of impact craters, the thickness of pyroclastic deposits, and the distribution of impact melt on the lunar surface, can be addressed. Especially, I will continue to study possible factors for the high radar echoes over the lunar polar regions, and compare the difference in radar echoes between the Moon and Mercury.

In addition, I plan to analyze Kaguya Lunar Radar Sounder (LRS) data to obtain a maria basalt thickness map. I will consider dielectric permittivity distribution across maria regions, and compare maria basalt thickness at the CE-3 landing site from the LPR data. Therefore, it will be possible to obtain a better maria basalt thickness map, and hence volume of maria basalts and the eruption rate of volcanism can be estimated with a higher precision.

1.2 Thermal Properties of the Lunar Regolith
The surface heat flow of the Moon is a fundamental measurement for determining its interior composition, structure, and evolution. Nevertheless, up to now, lunar heat flow was only determined in situ at the Apollo 15 and 17 landing sites. I plan to study the heat flow of the Moon globally using CE-1/2 microwave and Diviner infrared radiometer data. By resolving the one-dimensional heat transfer equation, the regolith temperature profile can be obtained, and its dependence on regolith thermal properties and internal heat flow can be investigated. Then, for a given temperature profile, microwave brightness temperature (TB) can be modeled using radiative transfer theory. By comparing the modeled TB with CE-1/2 observations, the subsurface temperature profile can be estimated. Finally, with the thermal conductivity estimated from Diviner observations, the internal heat flow of the Moon can be estimated and Apollo heat flow measurements can be used to validate the estimated heat flow.
I also plan to study the evolution of small craters using Mini-RF radar, Arecibo radar, microwave radiometer, and Diviner radiometer data. The small fresh craters have high radar backscatters and CPRs in radar images, and appear as cold and hot spots in microwave and infrared TB images. A combined study of radar and radiometer data can provide constraints on rock abundance, bulk density, and porosity of these craters (interior, continuous ejecta, and rays). Using surface ages of craters, the evolution of small craters can be investigated.

1.3 Planetary Surface Properties

Though lunar regolith thickness was estimated previously using different methods, there are still large uncertainties in the results, and there is no systematical study of the evolution of the regolith. With the release of high resolution optical images from recent missions and crater counting rules in my previous study, it is possible to estimate regolith thickness over large regions with a high precision. We will obtain a more reliable regolith thickness map using LROC images, and study the regolith accumulation rate in combination with surface age. We will further study the correlation between regolith thickness, surface age, and crater density. In addition, we plan to simulate regolith formation process using Monte Carlo simulations. This will show how regolith accumulates with time and the relation between regolith thickness, morphology and numbers of small craters.

The topography of a terrestrial planet results from a number of internal and external processes that shape its surface over a wide range of timescales. As a quantitative measure of topographic relief, roughness of a planet is a key parameter in distinguishing and identifying various geological processes affecting its surface. We plan to conduct a systematic comparison of surface roughness for Mercury, Venus, the Moon, and Mars. We will calculate a wide range of roughness parameters using topography data from different techniques (e.g., laser altimeter, radar altimeter, and stereo data), and investigate how roughness varies with scale. Finally, we will compare surface roughness between different planets, and quantify the major geologic processes reshaping their surfaces.

2. Teaching & Student Supervision

I plan to open a new undergraduate-level course, *Principles and Applications of Radar Remote Sensing*. This course will become one of the major courses in the framework of remote sensing and geographical information system. I have more than 10 years of experience in radar remote sensing, from basic principles to extensive applications in planetary explorations. Such experiences will be helpful for teaching the course.

I will continue to improve and update the lecture notes as well as to innovate the presentation style of my two courses, *Planetary Remote Sensing* and *Academic Writing for Graduate Students*. For *Planetary Remote Sensing*, I plan to write a textbook in Chinese for
graduate students, and I have now finished the first two chapters. For *Academic Writing for Graduate Students*, I am collecting teaching cases in order to make the lecture more interesting, and I plan to write an article on the rules of academic ethics for graduate students. As for the teaching style, I also plan to learn how to use MOOC (massive open online course) for lecturing, improve the teaching methods and tools, and embrace new teaching trends from the internet era.

I will continue to serve as the supervisor of the research program for undergraduate students supported by the university, helping the students to broaden their science vision and build up their research quality. I will also supervise graduate students to foster the next generation of Chinese planetary scientists.

3. Services

I will continue to serve as a member of the planning team of SESS, assisting the dean for future discipline plans. In addition, I will continue to deal with specific business tasks assigned by the department, the school, and the university. I plan to serve as a class advisor for undergraduate students (in 2017), and a mentor for undergraduate students. I also plan to give public lectures to undergraduate students in our school.

I plan to promote planetary sciences at Peking University: continue to organize the *Planetary Science Lunch Meeting*, invite top scientists to give lectures and visit our university, and organize workshops on planetary science.

I will continue to serve as the associate editor of *JGR-Planets*, the reviewer of the master and doctoral dissertations, scientific journal papers, and grant proposals.