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我国对苏梅克－列维 9 号彗星撞击木星事件的观测

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摘　　要

1994 年 7 月 16 日 —22 日，苏梅克－列维 9 号周期彗星的 21 颗碎片连续撞击木星事件是一次极为罕见的天文现象．文中概括介绍了我国天文学家对彗木相撞事件的光学和射电观测网点、课题设置以及所取得的主要观测结果．

关 键 词　彗星：苏梅克 — 列维 9 号 — 行星：木星

The Observations of the Collision of Comet P/Shoemaker –Levy 9 with Jupiter in China

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Abstract

The fragments of Comet P/Shoemaker-Levy 9 (afterhere Comet P/SL 9) impacted Jupiter on 16–22 July, 1994. Optical and radio observations were made in China. In this paper, we introduce the Chinese Watch Network for Comet P/SL 9–Jupiter Impacts, and the principal observation results of Chinese astronomers are shown.

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Key words comets: Comet P/SL 9–planets: Jupiter

1 Introduction

Comet and asteroid impacts have played an important role in the evolution of solar system. The collisions of Comet P/SL 9 with Jupiter provided the first opportunity to observe a major impact for astronomers. Observations of these impacts would provide much new information about the mechanics and energetics of collisions, and facilitate the interpretation of major prehistoric impacts on the Earth. The impact events also enable us to study the composition, structure and tidal evolution of comet as well as Jupiter's atmosphere and rings. The events also enable us to study directly the physical process of impact, which would contribute a better understanding of the prehistoric impacts on the Earth.

In China, many astronomers were involved in monitoring Jupiter, Comet P/SL 9 and Galilean satellites. From April 18 to April 20, 1994, "The Conference of Chinese Watch Mission for the Comet SL 9–Jupiter Impacts" was held in Nanjing, China. It was an important meeting, with 80 registered participants from Beijing Astronomical Observatory, Purple Mountain Observatory, Shanghai Astronomical Observatory, Yunnan Observatory, Nanjing University, Nanjing Normal University and so on. "The Group of Chinese Watch Coordination on the Comet P/SL 9–Jupiter Impacts" was established. After the conference, many astronomers watched the Jupiter, Comet P/SL 9 and Galilean satellites by the use of optical and radio telescopes at Chinese observatories.

In this paper, we introduce "The Chinese Watch Network for Comet P/SL 9–Jupiter Impacts" in Sec.2. The principal observational results are presented in Sec.3.

2. The Chinese Watch Network for Comet P/SL 9–Jupiter Impacts

2.1 Chinese Watch Network

At the Conference of Chinese Watch Mission for the Comet P/SL 9–Jupiter Impacts in Nanjing it was decided to establish the Chinese Watch Coordination Group for Comet P/SL 9–Jupiter Impacts with Prof. Li Qibin, director of Beijing Astronomical Observatory and Prof. Zhang Heqi, director of Purple Mountain Observatory as its president and vice-president, respectively. The list of divisions of this Group is as follows:

1. Division I: The Information Center (Beijing Astronomical Observatory)
2. Division II: The Prediction Center (Purple Mountain Observatory)
3. Division III: The Optical Observation Stations
    - (a) Xinglong Station of Beijing Astronomical Observatory (2.16m, 1.26m and 60cm telescopes + CCD)
    - (b) Fuzhou Station of Beijing Astronomical Observatory (35cm telescope+std CCD)

(c) Urumqi Station of Beijing Astronomical Observatory (30cm telescope+std CCD)

(d) Sheshan Station of Shanghai Astronomical Observatory (1.56m telescope+ series 200 CCD camera)

(e) Purple Mountain Observatory (40cm and 60cm telescopes)

(f) Qingdao Station of Purple Mountain Observatory (30cm telescope+CCD)

(g) Yunnan Observatory (1m and 60cm telescopes+CCD, 1.2m telescope+facular camera)

(h) Solar Tawer of Nanjing University (spectrometer+CCD)

4. Division IV: The Radio Observation Station

(a) Purple Mountain Observatory (decimeter wave antenna)

(b) Miyun Station of Beijing Astronomical Observatory (meter wave antenna)

(c) Xinxiang Station of Beijing Astronomical Observatory (decimeter wave antenna)

(d) Urumiq Astronomical Station (25m antenna, centimeter wave)

(e) Shanghai Astronomical Observatory (25m antenna, centimeter wave)

2.2 Information and prediction

From April 1994 to September 1994, the Chinese Information Center of Comet P/SL 9–Jupiter Impacts published 12 information letters. These letters fastly transmitted varied news and messages of International and Chinese Watch Network and were very useful for all observers.

Before the impact events, the independent prediction of impact time and location were made for each fragments of Comet P/SL 9 by Planetary Group of the Purple Mountain Observatory. The precision of the prediction was in consistency with the prediction of the Internet of Information Explorer System, and it provided important reference for every watch station.

3. The Principal Observation Results

According to the prediction, there were six impact events, i.e. the fragments D, E, K, N, P2 and S impact with Jupiter, could be observed in China. A large amount of optical and radio data, including the pre-impact, during impact and post-impact, were obtained from every watch stations. After primary data reduction, the principal observation results are as follows:

3.1 The observation of the impact events

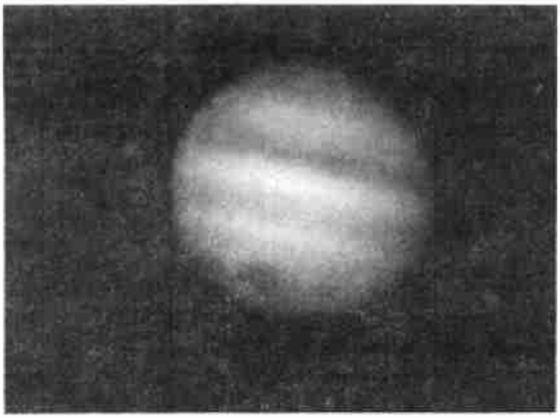

Fig.1 The whole Jupiter disk on 18 July, 1994 with 1.56m telescope and CCD camera of Shanghai Astronomical Observatory

About 2000 images of Jupiter were obtained from March to August, 1994. Espetially, the CCD photometry observations of Jupiter were made with optical telescopes of all stations and many images of Jupiter's surface were recorded during the impact week. From these images, we detected impact sites for 17 fragments, of which four fragments left no discernible disturbance. Table 1 shows the observation results of impact events of all wacth stations in China. Fig. 1 shows the whole Jupiter disk on 18 July, 1994 with CCD camera on 1.56m telescope of Shanghai Astronomical Observatory.

Table 1. The Observation Results of Impact Events during the Comet P/SL 9–Jupiter Impacts in China*

Fragment No.	Observation Date (July, 1994)					
	17^d	18^d	19^d	20^d	21^d	22^d
A=21		s			x	
B=20						
C=19						
D=18		s				
E=17		s	s	f,x,s	f,x,s	
F=16		y		f,s	f,x,s	
G=15		y,s		f,x,s,n	s	f,s
H=14			s	f,s	p,x	u
J=13						
K=12		f,s,p,x	f,s,p,x,y		f,u,p,x,s,n	f,s
L=11				n	u,s	f,s
M=10						
N=9				s,x		
P2=8b				s	f,u,p,x,s	
P1=8a						u,s
Q1=7b						
Q2=7a						
R=6						s
S=5					s,u	s,u
T=4						s,u
U=3						s,u
V=2						s,u
W=1						s,u

* f=Fuzhou Station of Beijing Astronomical Observatory, n=Solar Tawer of Nanjing University, p=Purple Mountain Observatory, s=Sheshan Station of Shanghai Astronomical Observatory, u=Urumqi Station of Beijing Astronomical Observatory, x=Xinglong Station of Beijing Astronomical Observatory, y=Yunnan Observatory

3.2 The monitoring of Galilean satellites

Because the impact events are located on the dark side of Jupiter, we can study the impact process only by the flash reflection from Galilean satellites at the time when fragments D, E, K, N, P2 and S fell in Jupiter atmosphere and burned themselves. The monitoring of Galilean satellites were made in Sheshan Station of Shanghai Astronomical Observatory for impact week. Eight light curves of Galilean satellites were reduced with estimeted standard error σ for each light curves. The observation parameters on the impacts of fragments D, E, K, N, P_2 and S are listed in Table 2. However, the attempts to observe this effect were disappointing for fragments D, E, N and S, and the possible flashes were observed for fragments K and P_2. The brightness of the monitored satellites were increasingly faint. In order to indentify whether or not these flashes are real, data reduction and analyses are under processing.

Table 2. The Observation Parameters of the Fragments D,E,K,N,P_2 and S of Comet P/SL–9 Impact to Jupiter

Fragment	Observation Times(UT) (July,1994)	Expose Time	Filter	Monitored Satellites	Maximun Time(UT) (July,1994)	1σ	Magnitude Differences
D=18	$17^d11^h48^m41^s$ $-17^d12^h01^m02^s$	$0.^s1$	I	Io	$17^d11^h56^m50^s$	0.034280	1.789676σ
E=17	$17^d14^h28^m48^s$ $-17^d15^h30^m18^s$	$0.^s1$	I	Ganymede	$17^d15^h05^m09^s$	0.204342	1.577827σ
E=1	$17^d14^h28^m48^s$ $-17^d15^h38^m27^s$	$0.^s1$	I	Io	$17^d15^h09^m06^s$	0.310383	1.420981σ
K=12	$19^d10^h22^m34^s$ $-19^d10^h34^m33^s$	$0.^s05$	V	Io	$19^d10^h25^m40^s$	0.110921	2.786104σ
N=9	$20^d10^h13^m00^s$ $-20^d10^h45^m07^s$	$0.^s03$	V	Europa	$20^d10^h29^m14^s$	0.110708	2.296925σ
P2=8b	$20^d15^h06^m20^s$ $-20^d15^h23^m15^s$	$0.^s5$	V	Io	$20^d15^h22^m18^s$	0.117453	2.060030σ
P2=8b	$20^d14^h56^m47^s$ $-20^d15^h22^m18^s$	$0.^s5$	V	Europa	$20^d15^h21^m22^s$	0.076147	2.420742σ
S=5	$21^d14^h50^m55^s$ $-21^d15^h15^m58^s$	$5.^s0$	I	Callisto	$21^d15^h21^m22^s$	0.136595	1.696514σ

3.3 Impact time of fragment P_2

According to the observation data from the Hubble space telescope, Galileo Spacecraft and many ground-based infrared telescope, Chodas and Yeomans have been appeared the post-impact estimates of impact time[1]. For comparison, it is listed in the Table 3. However, in their list there is not primary source of impact time for fragment P_2. Up to now, no one has reported the observation data about fragment P_2 except Sheshan Station of Shanghai Astronomical Observatory. Fig. 2–3 show the light curves of Io and Europa during the impact of fragment P_2 with Ju-

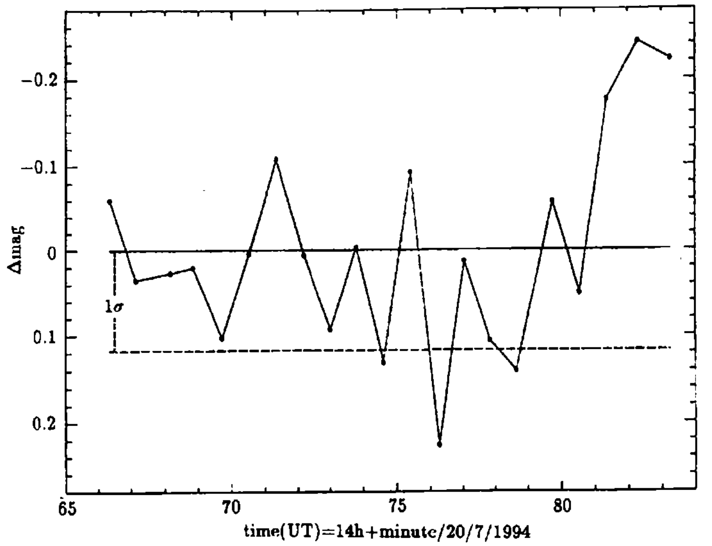

Fig.2 light curve of Io, frag. P2=8b impact

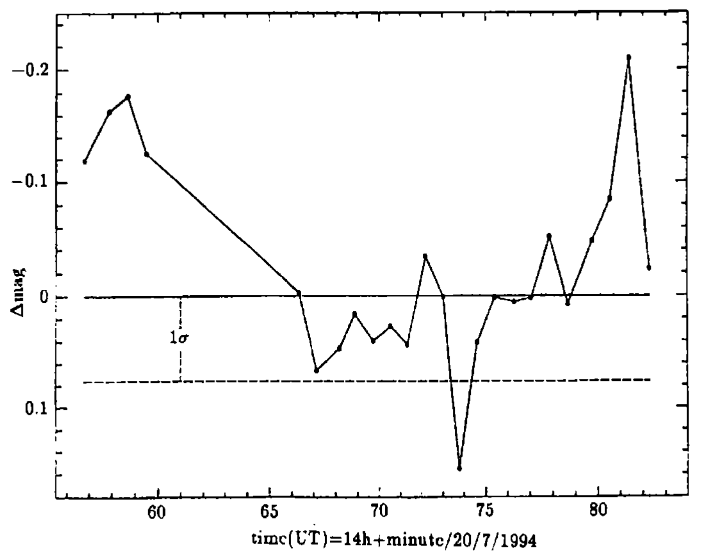

Fig.3 light curve of Europa, frag. P2=8b impact

piter. From Table 2–3 and Fig. 2–3, we can show that there are maximum magnitude difference in the light curves of Io and Europa during the P_2 impacts with Jupiter. The times of both peak values are almost consistent with accepted impact time. It implies that the accepted impact time of fragment P_2 we determined might be July $20^d15^h21^m22^s \pm 1^m$.

3.4 The radio observations at decimeter wave band

The radio observation played an important role in the impact events, as the radio bursts could be detected before impact time. Three strong decimeter radio bursts (> 20db), undoubtedly,

Table 3. Post–Impact Estimates of the Impact Time[1]

Fragment	Date July	Accepted Impact Time(UT)	1σ (min)	Primary Source of Time
A=21	16	19 : 20 : 11	±4	Calar Alto
B=20	17	02 : 02 : 53	±4	Keck
C=19	17	07 : 07 : 12	±4	IRTF
D=18	17	11 : 11 : 54	±4	ANU/AAT
E=17	17	15 : 15 : 11	±3	Calar Alto
F=16	18	00 : 00 : 33	±5	Lowell
G=15	18	07 : 33 : 32	±1	Galileo PPR
H=14	18	19 : 31 : 59	±1	Galileo PPR
J=13	19			
K=12	19	10 : 24 : 14	±1	Galileo SSI
L=11	19	22 : 16 : 48	±1	Galileo PPR
M=10	20			
N=9	20	10 : 29 : 17	±1	Galileo SSI
P2=8b	20	15 : 15 : 23	±7	
P2=8a	20			
Q2=7b	20	19 : 19 : 44	±6	Pic du Midi
Q1=7a	20	20 : 20 : 13	±3	Pic du Midi
R=6	21	05 : 05 : 34	±3	Keck/Palomar
S=5	21	15 : 15 : 15	±5	SAAO
T=4	21	18 : 18 : 10	±7	
U=3	21	21 : 21 : 55	±7	
V=2	22	04 : 04 : 23	±6	Palomar
W=1	22	08 : 96 : 12	±1	Galileo SSI

related to the impacts of fragments G, K and W of Comet SL 9 on Jupiter on July 18, 19 and 22, were detected during the impact week at Xinxiang Temporary Jovian Decimetric Watch Station of Beijing Astronomical Observatory. All of them are narrow band events occurred at about 26.0MHz and 28.5MHz, and had a long duration of at least several minutes. Their completely different characteristics, i.e. the strongest one before G impact, immediate response to K impact, and swithing burst after W impact, have been analysed. Fig. 4–5 show that both the strong decimeter radio bursts of impacts of fragments G and K, where ΔI and ΔF present the impact time and fireball appeared time of infared observation respectively.

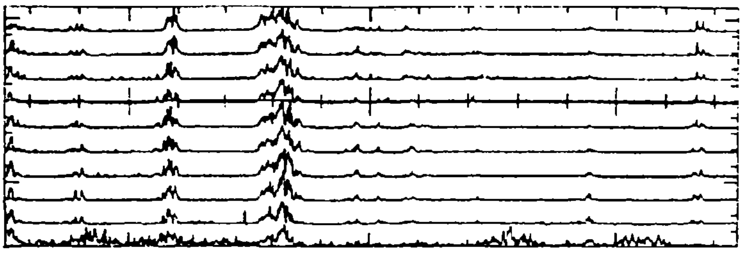

Fig.4 The scan observation of Jupiter from UT:14^h05^m to 14^h55^m.
The frequencies from bottom to top are 24.0 MHz to 28.5 MHz with a step of 0.5 MHz

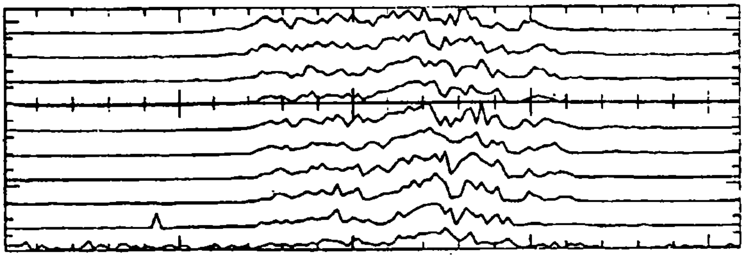

Fig.5 The particular burst was taken from Fig.1. The UT range are from 14^h20^m to 14^h27^m

References

[1] Chodas P W, Yeomans D K. Abstract in 26th Meeting of Division for Planetary Sciences of the American Astronomical Society, Washington DC, USA, October 31–November 4, 1994.