Prelir ary Results of the Earth's Free Oscillations after P u Earthquake Observed using a SG in China

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Abstract: We investigated the Earth's normal modes excited after the June 23, 2001 Peru Earthquake recorded with the superconducting gravimeter at station Wuhan/China. After removing effectively the tidal gravity and pressure perturbation signals, all the base normal modes from ${}_0S_0$ to ${}_0S_{32}$, the splitting modes of the ${}_0S_2$ and ${}_0S_3$ and some of the harmonic modes are observed obviously.

1 Introduction

It is well known the large earthquake can not only excite the Earth's body and surface waves, but also the Earth's free oscillation (EFO). Comparing those in the theoretical prediction, the EFO can provide us with the information independently to the seismology in researching for the variation of the Earth's inner geophysical properties (Crossley and Hinderer, 1994). The first two successful observations of the EFO are based on the strainmeter (Benioff et al 1961) and spring gravimeter (Ness et al 1961), their results coincided with theoretical estimations.

The studies show that the gravity recording can embody the signals of the spheriodal modes of the EFO. The superconducting gravimeters (SG), which possesses a very wide linear dynamic range, low noise and instrumental drift, are now considered as the most reliable instruments in the investigation of the small change in the Earth's gravity field. The global network of the SG become now the main tool in the study of the geophysical and geodynamic problems around world (Sun and Xu, 1997). The basic normal and harmonic modes observed with the SG after the 1996 Irian and the 1998 Baleny large earthquakes have been investigated by Van Camp (Van Camp, 1999). In this paper, we will check all the basic normal modes of the EFO between ${}_0S_0$ and ${}_0S_{32}$, the splitting models of the ${}_0S_2$ and ${}_0S_3$ and some harmonic modes by analyzing the SG data at Wuhan station, after Peru Ms 7.9 earthquake at 20:33:16 on June 23, 2001 (latitude: 16.00°, longitude: 73.70°W).

2 Techniques of the data processing

The influence of long-term gravity variation might be neglected, when checking the EFO modes by using the SG data after the large earthquake. The sampling of the Wuhan SG observation is given as 20 s, the total numbers of the data used in this study is 23,500. The spline interpolation method at the order of 3 is used in order to obtain the pressure data rate of 20 s from origin 10 minutes sampling. Some perturbations as spikes and small earthquake events are corrected .

The former researchers (Ness et al, 1961 and Van Camp, 1999) removed the tidal gravity signals from observations by using digital filter, when the EFO modes are checked. However, in our study, the least square polynomial fitting is adopted to remove fragmentally gravity tides (Ding, 1997). We fit the data points in total of 4,000 (about 22 hours) once, by taking fitting polynomial at order of 20. The former 8,000 points are divided into two sections and the points between 10001 and 23500 are divided into four sections. The analysis shows that taking the polynomial at the order of 20 is enough for removing the two standing and two inflexion parts in the data section.

By integration theoretically the atmospheric gravity Green's function with the pressure around station, the pressure gravity admittance as of -0.3603 mGal/hPa is obtained (Sun, 1997). By taking a regression between the SG tidal gravity residuals and the station pressure, a regression coefficient at station Wuhan is got as of -0.307 mGal/hPa (Xu et al 1999). The results show that the discrepancy is small when using the above two coefficients to correct pressure influence in the EFO band. Then an average value as of -0.326 mGal/hPa is adopted in our study. The results show that the tidal polynomial fitting could eliminate signals at the low frequency normal modes that will probably influence the resolution. The EFO modes are then calculated by applying the Discrete Fourtier Transform to tidal gravity residual.

The station noise is necessary to be taken into account before checking the EFO modes, it is reasonable to take the noise in a quite earthquake period as normal one and to remove them from the data set (Banka, 1998). If the checked EFO modes signals are larger than 3 time of the normal noise level, then these modes are adopted automatically in the computation procedure.

3 Results and discussions

The spectral results of the EFO modes are given in figures 1, 2 and 3, it is found that all the base modes from ${}_0S_0$ to ${}_0S_{32}$ are clearly shown, some numerical results are given in table 2. In order to comparison, the HB1 model and some results obtained by Benioff et al and Ness et al are also listed. In table 2 it is found that the splitting modes of the ${}_0S_2$ and ${}_0S_3$ are also observed obviously. All the base modes between ${}_0S_4$ and ${}_0S_{32}$ observed with our SG are in accordance with those given in the HB1 model and those observed with the strainmeter and the spring gravimeter. The discrepancy is generally not more than 2.0‰. Some harmonic modes observed with our SG are shown in Fig.2.

We successfully observed the spheriodal modes of the EFO by using SG C032 at station Wuhan/China. Different from the former researchers, the gravity tides are removed fragmentally by using with a polynomial fitting at order of 20. In the period between 140 to 250 s, the EFO modes with frequency higher than ${}_0S_{32}$ are observed. Many basic and harmonic modes are in good agreement with those in the publications, but some disagreement are probably related to the heterogeneity of earth mantle. It is believed that some satisfying answers for these problems will be obtained in the future Global Geodynamic Project.

Table2 Observational and theoretical periods of all normal modes form ${}_0S_0$ to ${}_0S_{32}$

modes	P(1) /m	P(2) /m	P(3) /m	P(4) /m	modes	P(1) /m	P(2) /m	P(3) /m	P(4) /m
${}_0S_0$		20.46	20.45	20.48	${}_0S_{17}$	6.48	6.488	6.490	6.495
${}_0S_2$	53.1-54.7	52.80-54.98	53.22-56.23	53.78	${}_0S_{18}$	6.23	6.232	6.237	6.237
${}_0S_3$	35.2-35.9	35.24-35.87	35.28-35.82	35.59	${}_0S_{19}$	6.01	6.002	6.003	6.002
${}_0S_4$	25.8	25.85	25.77	25.78	${}_0S_{20}$	5.78	5.778	5.790	5.790
${}_0S_5$	19.8	19.83	19.78	19.85	${}_0S_{21}$	5.59	5.608	5.599	5.597
${}_0S_6$	16.0	16.07	16.05	16.07	${}_0S_{22}$	5.39	5.423	5.417	5.420
${}_0S_7$	13.5	13.42	13.53	13.54	${}_0S_{23}$	5.26	5.255	5.250	5.255
${}_0S_8$	11.81	11.78	11.80	11.80	${}_0S_{24}$	5.10	5.104	5.107	5.103
${}_0S_9$	10.56	10.57	10.57	10.56	${}_0S_{25}$	4.96	4.959	4.961	4.962
${}_0S_{10}$	9.66	9.685	9.671	9.657	${}_0S_{26}$	4.83	4.828	4.823	4.828
${}_0S_{11}$	8.98	8.934	8.932	8.952	${}_0S_{27}$	4.69	4.703	4.708	4.705
${}_0S_{12}$	8.37	8.368	8.369	8.377	${}_0S_{28}$	4.59	4.585	4.578	4.587
${}_0S_{13}$	7.88	7.882	7.889	7.892	${}_0S_{29}$	4.47	4.476	4.461	4.475
${}_0S_{14}$	7.47	7.468	7.467	7.473	${}_0S_{30}$	4.37	4.366	4.376	4.370
${}_0S_{15}$	7.10	7.101	7.102	7.107	${}_0S_{31}$	4.27	4.270	4.274	4.270
${}_0S_{16}$	6.78	6.780	6.776	6.783	${}_0S_{32}$	4.18	4.167	4.171	4.175

Note: P(1) and observed by Benioff at el with strainmeter, P(2) given by Ness at el with spring gravimeter, P(3) investigated by us with SG C032 and P(4) provided by HB1 model

Acknowledgement This work is supported jointly by the National Natural Science Foundation of China (grant Nos. 40074018 and No. 49925411).

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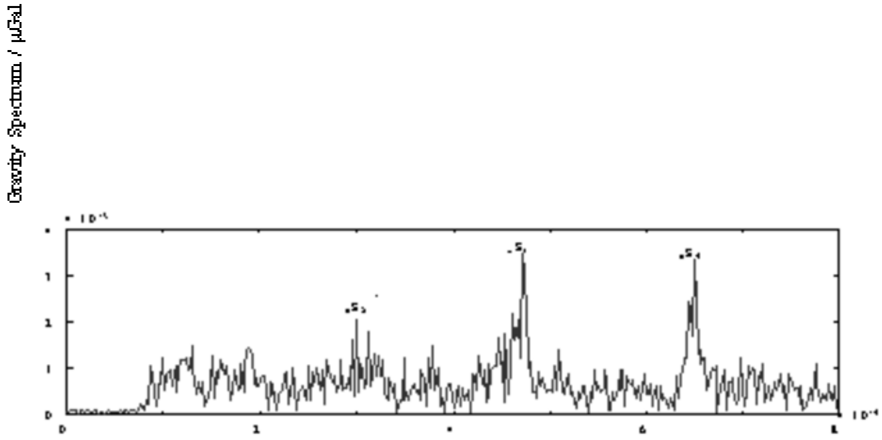

Figure 1 Free oscillation spectrum (0-0.8 mHz)

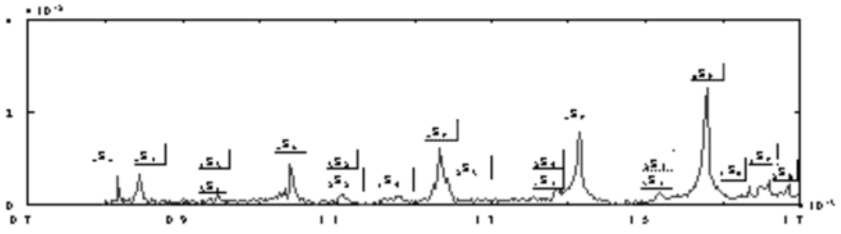

Figure 2 Free Oscillation Spectrum (0.8~1.7mHz)

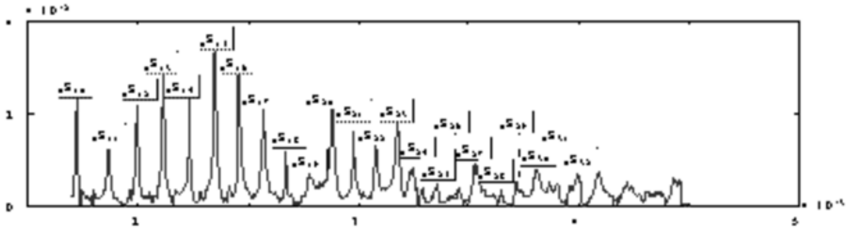

Figure 3 Free Oscillation Spectrum (1.7~4.5mHz)