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6C seismic observations in China

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A complete six-component (6C) seismic wave field includes three translational components and three rotational components. Traditional seismic observation and research only focus on the translational motions, but exploration of rotational seismology has a long history (Aki and Richards,2002; Lee et al.,2009). With the development of rotational seismometers, especially the high-precision optical rotational seismometers, further investigation on the rotational motions have raised gradually. Rotational seismology could be applied in strong-motion, broadband seismology, earthquake engineering and many other fields (Igel et al.,2005; Schmelzbach et al.,2018).

In recent years, we have carried out several 6C seismic observations in many regions of China, including earthquake observations in Quanzhou and Lijiang, test of rotational seismometers and deep underground observation in Huainan and engineering seismic experiments in Tangshan.

The additional wave field brought by rotational components help to estimate phase velocity of shallow media (Wassermann et al.,2016). In September 2020, we executed a shallow seismic experiment in Tangshan, China. The test field locates in an abandoned coal area, backfilled with building trash and surround by traffic lines. In this experiment, four types of seismometers were installed to record 6C seismic records, including eentec R-2 molecular-electronic rotational seismometer and FOSN-II fiber-optic rotational seismometer. The seismic signals was excited by a conventional hammer and a 3-directional controlled vibration. Results show that the fundamental Rayleigh wave dispersion curve calculated by single-station 6C observation is consistent with the dispersion curves extracted with array of geophones.

High precision rotational observation depends on stations with low ambient noise. The use of deep underground space for geophysical observation has great advantages. A typical example is the ring laser gyroscope GINGERino located within LNGS (Laboratori Nazionali del Gran Sasso, the underground INFN laboratory) in central Italy (Simonelli et al.,2016; Belfi et al.,2017). Using the underground tunnel space of the discontinued Huainan Panyi-East Coal Mine (848 meters underground) in China, we have deployed several multi-physics joint observations since 2020 (Wang et al.,2023). The 6C seismic observation has used a variety of broadband seismometers and fiber-optic rotational seismometers (Chen et al.,2022). Results indicate that the fiber-optic rotational seismometers could record the teleseismic rotational signals with an epicentral distance of about 1000 km, and the rotational components is helpful to estimate the back azimuth of earthquake and the phase velocity of surface wave.

In the future, more 6C seismic observations will be applied to deep underground observation, construction engineering, marine seismic experiment, site effect and other research in China.

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