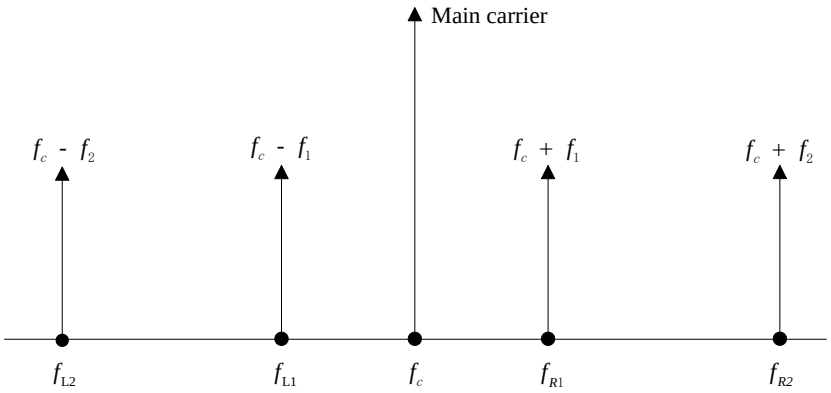

Fig.1 X-band DOR signals. The tones are generated from modulation on the downlink carrier signal. f_c is the main carrier, f_{L1} and f_{R1} are narrow spanned bandwidth tones, f_{L2} and f_{R2} are wider spanned bandwidth tones.

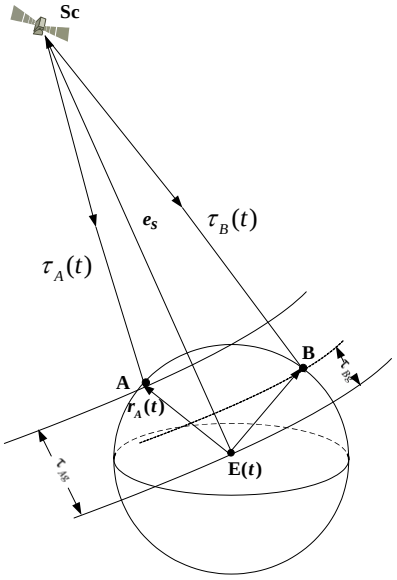

Fig. 2 DOR tracking geometry of a spacecraft, and the different models used in VLBI FX correlator and local correlation. $\tau_{Ag}(t)$ and $\tau_{Bg}(t)$ are used by FX correlator for time-shifting the signal from topocentric to geocentric frame. $\tau_A(t)$ and $\tau_B(t)$ are used by local correlation for eliminating Doppler shift.

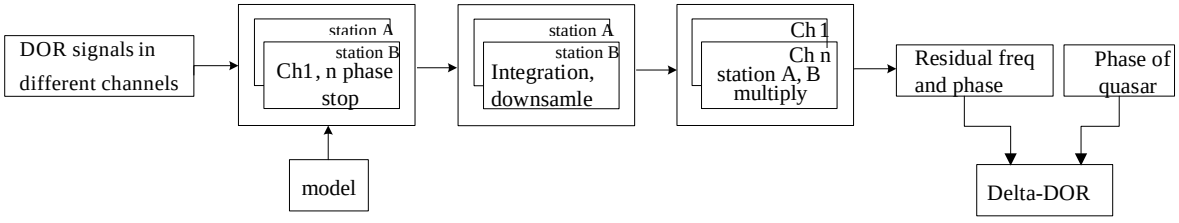

Fig. 3 DOR correlation flowchart

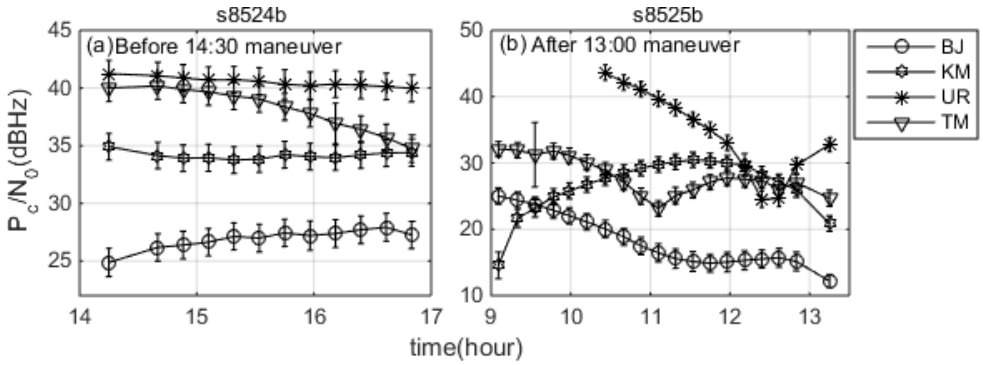

Fig.4 P_c/N_0 of Longjiang-2 DOR main carrier in s8524b and s8525b. Ur didn't attend spacecraft observation until 10:23 because of low elevation in s8525b.

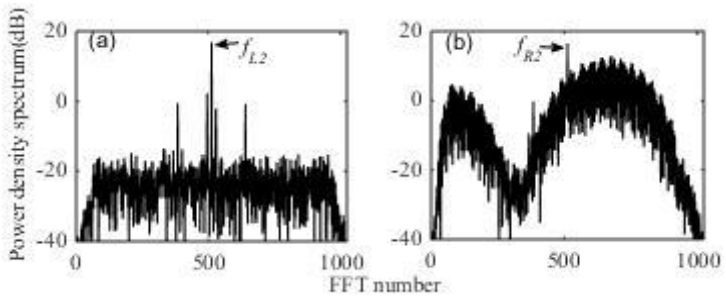

Fig.5 Power density spectrum of DOR tones and data-transmission signal from Chang'E 3 lander. Integration time is 5 s, spectral resolution is 2 KHz, sample rate is 4 MHz, bandwidth is 2 MHz, quantification is 2 bit. Comparing with f_{L2}, f_{R2} is serious interfered by data-transmission signal.

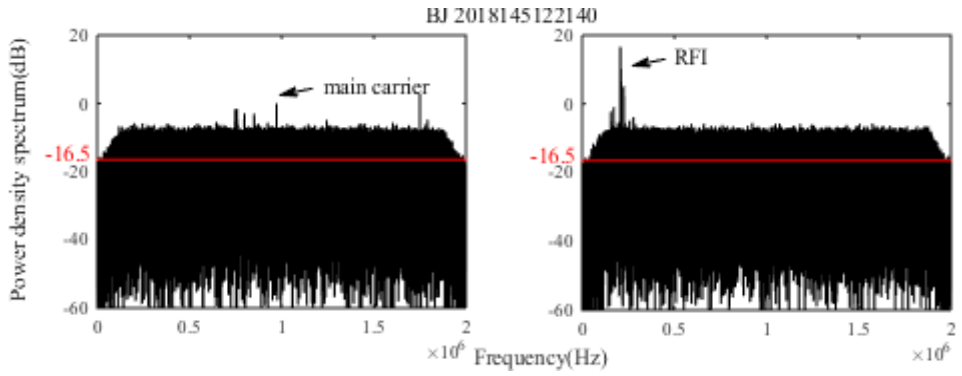

Fig. 6L Power density spectrum of the main carrier and the tone in BJ. Left: Spectrums of raw data, integration time is 1 s. The red lines are noise density. P_c/N_0 is 16.5 dBHz. The tone is totally submerged in the noise.

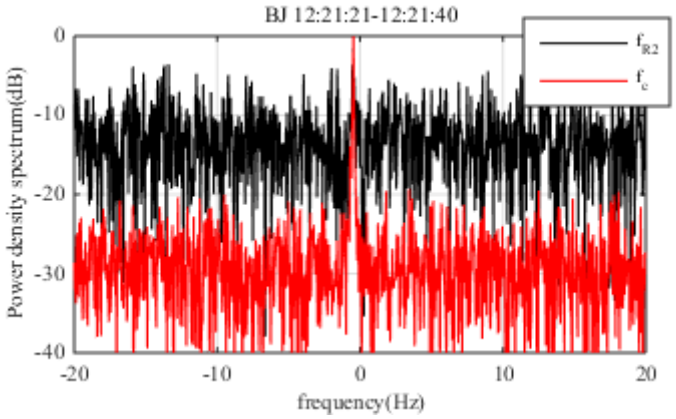

Fig. 6R Right: Spectrums after phase stop and integration, integration time is 20 s. P_{tone}/N_0 and P_c/N_0 increase to 13 dBHz and 30 dBHz respectively.

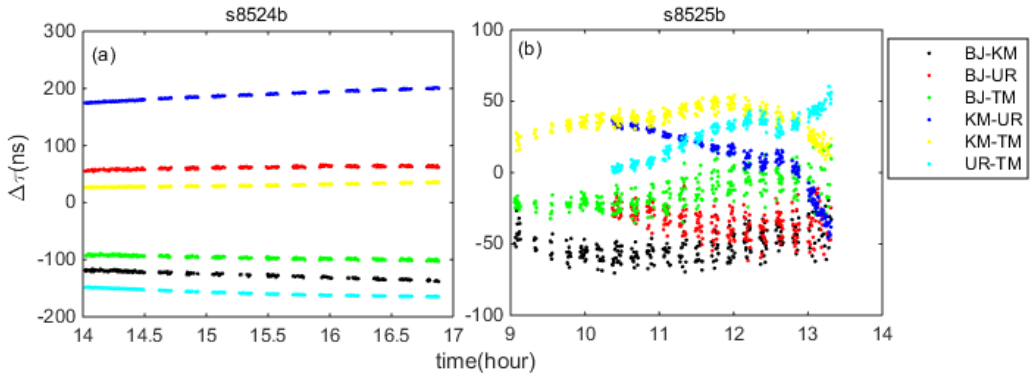

Fig. 7 Residual delay from s8524b and s8525b