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The Netherlands-China Low Frequency Explorer (NCLE)

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In radio astronomy, the very low frequency (VLF) range, below30 MHz, as one of the last remaining unexplored spectrum regions, plays an important role to understand comprehensively the physical processes of celestial sources by observing their emissions in the entire detectable EM spectrum. However, the artificial radio frequency interference (RFI), the cutoff frequency of the Earth's ionosphere, the AKR and QTN noise make it difficult or impossible to observe the sky VLF radio emissions with terrestrial telescopes. To open up this remaining spectral window virtually, a spaceborne telescope turns to be the only possibility. The Netherlands-China Low Frequency Explorer (NCLE) is a scientific radio instrument aiming to perform the radio observations at the VLF spectrum region. It operates at the frequency band from 80 kHz to 80 MHz. NCLE consists of three 5 m monopole antennas to receive the celestial radio emissions. The radio signals sensed by the antennas are digitized by an ADC board, and then the data are processed in a Digital Receiver System (DRS) on which several dedicated science modes are implemented in a Field Programmable Gate Array (FPGA). These scientific modes perform fast Fourier transforms to create average radio spectra, triggering to capture a short segment of the digitized signal for transient radio events, and beam-forming to map the radio sky. Raw time traces can be stored for the VLBI experiments or other ground-based post processing. More scientific analysis will be done after the data are sent back to the Earth. NCLE was developed by a joint scientific and engineering team including Chinese researchers and Dutch researchers. On May 21, 2018, it was launched onboard ChangE-4 relay satellite to an operating orbit around the Earth-Moon L2 point. In the commission phase, preliminary tests and experiments have been done with NCLE for the instrument’s safety checking and functional verification. Before the antenna deployment, the desired measurements with different system configurations were accomplished to support the next instrument calibration and radio frequency interference (RFI) mitigation. In November 2019, the three antennas of NCLE were deployed as expected, the virtual radio observations with NCLE finally began. In this work, the development and progress of NCLE will be reported and discussed including the functional tests, background measurements, and the antenna deployment, etc. Some preliminary observations will be also presented to demonstrate the capability of NCLE.