# Establishment of real-time analysis method in a new HRO interferometer system and operation test of comprehensive meteor observation

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Meteors are natural phenomenon that dusts is space with several millimeters to several centimeters in diameter in outer space jump into and collide with upper atmosphere of the earth, vaporizing and getting hot because of adiabatic compression by aerodynamic heating with emitting light at the same time. At the moment, thermal energy by aerodynamic heating make molecules in the atmosphere ionize, with generating a large amount of plasma. This plasma makes a elongated dense-ionized column along the meteoric trajectory. Meteor radio observation is an observation method using scattered radio waves by free electrons in the ionized column. In this research, at Kochi University of Technology (KUT), we conducted Ham-band radio meteor observation (HRO) in forward scattering method using the 53.755 MHz VHF (amateur band) wave that is transmitted stably from Fukui Prefectural University.
The objective of this research is that we apply a new observation method and analyzing algorithm to KUT 5ch meteor radio interferometer and develop meteor research using 5 antennas of the meteor radio interferometer [1]. Because of the limited radio meteor observation in Japan, if we share accurate observation method and observation result with the other observers, we can contribute to the development of study on meteor science.
In this research, we conducted three methods (comprehensive meteor observation [1]) of the new HRO interferometer system (HRO interferometer system), optical observation, and infrasound observation.
In the HRO interferometer system, after the signal received at the antennas was demodulated in their receivers, with making input to an observation PC through an AD board, real-time processing by analysing software on the PC was performed. A group of data set triggered only when exceeding a threshold set in advance on the software are saved as a meteor echo. In the analysis of meteor plasma direction of each meteor with considering intrinsic phase difference, we calculated each phase difference in north-south and east-west directions with baseline length of 0.5 $\lambda$ and 2.5 $\lambda$ ( $\lambda$ is observation wavelength ), after processing interference calculation among signals of multiple antennas using 5ch meteor radio interferometer [1].
In the optical observation, we used existing high sensitivity B/W CCD camera (WAT-100N) and color 4K camera (Sony, $\alpha$6300) newly installed with a combination of UFOCaptureV2 and HD2 that are motion capture software. The observation data was analyzed from the information recorded by cameras by analyzing position, velocity, linearity of motion, etc. by using UFOAnalyzerV2 for data stored through UFOCaptureV2 and HD2.
In the infrasound observation, we conducted a unique meteor observation for such as large fireballs by using a group of infrasound sensors that can observe very low frequency sound of less than 20 Hz caused by large scale natural phenomena. It is possible to estimate energy scale of the meteor entry from obtained amplitude and period of the sound wave.
In order to determine the intrinsic phase shift, we searched for the observability of the same phenomenon for the comprehensive meteor observation data.
In this research, we obtained 2 meteor shower data from August 2018 to January 2019. Especially, in 2019 at Quadrantids, three candidates of the intrinsic phase shift was obtained by analysis of comprehensive meteor observation data, but we could not confirm the intrinsic phase shift.

 

As a result of this research, we obtained the candidate values necessary for accurate calculation of meteor plasma direction by the interferometer data processing. Due to lack of the observation data, we could not confirm the intrinsic phase shift, thus after checking the analyzing process, we will continue to use the system and obtain more data to establish the intrinsic phase shift and ensure the accuracy and reliability of the observation method.
We applied the new trial called real-time analyzing to KUT 5ch radio meteor interferometer with confirming the validity of the new receiver system, and obtained the candidate values of the intrinsic phase shift necessary for our future research. We shared a part of accurately obtained data on the web and a mailing lists, so as to contribute to the development of meteor science.

References
[1] Satoshi Mizumoto, “Calculation of meteor orbit by multiple-site radio observation and construction of a comprehensive meteor observation system”, Master thesis, 2017.

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