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Study of meteor echoes with the BRAMS radio interferometer

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BRAMS (Belgian RAdio Meteor Stations) is a Belgian radio forward scatter system with one dedicated transmitter located in Dourbes, and about 25 receiving stations spread out over the Belgian territory (Lamy et al., 2015). The transmitter emits towards the zenith a circularly polarized continuous wave at 49.97 MHz with a power of 150 watts. At each receiving station, data are recorded continuously as audio WAV files of 5 minutes duration.

A typical BRAMS receiving station consists in a 3-element Yagi antenna, a commercial receiver, an external sound card (acting as the ADC), a BRAMS calibrator (for amplitude and frequency reference) and a GPS clock to ensure synchronization between all BRAMS receiving stations. The 3-element Yagi antenna has a very broad radiation pattern in order to cover a large portion of the sky where meteor trails are likely to appear. Therefore when using data from a single BRAMS receiving station, the direction of the specular reflection point of a meteor echo is not known. One station, located in the radio-astronomical site of Humain, in the South-East of Belgium, is a radio interferometer and is able to retrieve the direction of arrival of a meteor echo to an accuracy of the order of 1°. The principle proposed by Jones et al. (1998) is based on phase difference measurements between 5 antennas aligned along 2 perpendicular axes and separated by adequate numbers of wavelength in order to find a unique solution and avoid mutual impedance effects. The technique is largely used in meteor radars worldwide. The design of the BRAMS interferometer will be briefly presented.

Results for various types of meteor echoes observed with the radio interferometer will be shown: underdense meteor echoes with high and low signal-to-noise ratios, overdense meteor echoes and the so-called epsilon (or corkscrew) meteor echoes, named after their particular shape in spectrograms. In particular, the origin of the epsilon meteor echoes is possibly due to multiple reflections on various parts of the ionized trail, distorted by shear effects of mesospheric high-altitude winds. In that case a slight change of the direction of the meteor echo may be expected both in frequency (along the various branches) and/or with time.

The direction of arrival of the various meteor echoes must be calibrated. For that purpose, results using 3 different methods will be presented: 1) using the BRAMS calibrator as a transmitter and a calibrated antenna both attached to a drone flying in the far-field of the interferometer, 2) using the signal reflected from a plane whose position can be accurately determined (e.g. using websites such as Flight Tracker), 3) using optical observations provided by the CAMS-Benelux network (e.g. Roggemans et al. 2016). The CAMS (Cameras for All Sky Meteor Surveillance) network provides very accurate trajectories of meteors and can therefore be used to compute the theoretical positions of the reflection points for the observed meteor echoes.

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2. Jones J., Webster A. R., and Hocking W. K. (1998), "An improved interferometer design for use with meteor radars". Radio Science, 33, 55–65.

3. Roggemans P., Johannink C., and Breukers M. (2016), "Status of the CAMS-BeNeLux network". In Roggemans A. and Roggemans P., editors, Proceedings of the International Meteor Conference, Egmond, 2–5 June 2016. IMO, pages 254–260.