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Practical and Accurate Calculations of Radio Emission from Extensive Air Showers

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We present a novel semi-analytical treatment of the radio emission of air showers that is able to reproduce the results of full ZHAireS simulations, in theory at a fraction of the computational cost. Traditionally, the contribution to the vector potential of every single particle track in the shower is calculated separately. Instead, in our approach we divide the air shower into 4-D spacetime volumes, so that the contribution of the whole bin needs to be calculated only once, based on the average particle track inside it. This almost amounts to a macroscopic treatment of the shower, but retaining the precision of the successful microscopic approach.

The size of the 4-D spacetime volumes is chosen so that the traditional vector potential expression can be further simplified, as many of its terms can be taken to be the same for the whole bin. Computationally expensive terms, such as the the effective refractive index from the track to the observer, can then be calculated only once, making it possible to obtain the precise radio emission at a fraction of the cost.

This approach also allows us to perform more precise calculations that would otherwise be too expensive to apply on a track-by-track basis. These could include a more detailed treatment of atmospheric effects for near horizontal showers and high altitude detectors, such as balloons and satellites.

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