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Creating a Hydrodynamic simulation of Cygnus OB2

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The Cygnus X star-forming region has been of great interest to the high-energy astrophysics community due to the diffuse gamma-ray emission detected by Fermi, HAWC and LHASSO in recent years. At the heart of this region lies the OB association Cygnus OB2, with tens of powerful O stars and 3 Wolf-Rayet stars. It has been argued that efficient stellar wind interactions in the vicinity of massive star clusters create favourable conditions for particle acceleration up to very high energies, which could potentially explain the observed diffuse gamma-ray emission in this region. However the core of Cygnus OB2 is rather extended, which puts into question the appropriateness of simplified spherical models and calls for a more detailed investigation of the wind-wind interaction given the peculiarity of the region.

In this poster, we describe a large-scale hydrodynamic simulation of a massive star cluster whose stellar population mimics that of the Cygnus OB2 association, as a collaborative project between research groups specialising in both particle acceleration theory and winds of massive stars. The main-sequence stars are first simulated during 1.6 Myr, until a quasi-stationary state is reached. At this time, the three Wolf-Rayet stars observed in Cygnus OB2 are added to the simulation, which continues to 2 Myr. Using a high-resolution grid in the centre of the domain, we can resolve the most massive stars individually, which allows us to probe the kinetic structures at small (parsec) scales. We find that, although the cluster excavates a spherical "super-bubble"cavity, the stellar population is too loosely distributed to blow a large-scale cluster wind termination shock, and that collective effects from wind-wind interactions are much less efficient than usually assumed. This challenges our understanding of the ultra-high energy emission observed from the region. This work includes detailed treatment of the massive stellar population, incorporating Gaia astrometric data, empirically determined mass loss and terminal wind velocities for the most powerful stars, and stellar evolution. In this poster we will emphasise how these considerations directly affect results of interest to the high-energy astrophysics community.

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