Predicted gamma-ray line emission from the Cygnus complex

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The Cygnus region harbours a huge complex of massive stars at a distance of 1.0-2.0kpc from us. About 170 O stars are distributed over several OB associations, among which the Cyg OB2 cluster is by far the most important with about 100-120 O stars. These massive stars inject large quantities of radioactive nuclei into the interstellar medium, such as 26Al and 60Fe, and their gamma-ray line decay signals can provide insight into the physics of massive stars and core-collapse supernovae. Past studies of the nucleosynthesis activity of Cygnus have concluded that the level of 26Al decay emission as deduced from CGRO/COMPTEL observations was a factor 2-3 above the predictions based on the theoretical yields available at that time and on the observed stellar content of the Cygnus region. We reevaluate the situation from new measurements of the gamma-ray decay fluxes with INTEGRAL/SPI (presented in a previous paper) and new predictions based on recently improved stellar models. We built a grid of nucleosynthesis yields from recent models of massive stars. Compared to previous works, our data include some of the effects of stellar rotation for the higher mass stars and a coherent estimate of the contribution from SNIb/c. We then developed a population synthesis code to predict the nucleosynthesis activity and corresponding decay fluxes of a given stellar population of massive stars. The observed decay fluxes from the Cygnus complex are found to be consistent with the values predicted by population synthesis at solar metallicity; and yet, when extrapolated to the possible subsolar metallicity of the Cygnus complex, our predictions fail to account for the INTEGRAL/SPI measurements. The observed extent of the 1809keV emission from Cygnus is found to be consistent with the result of a numerical simulation of the diffusion of 26Al inside the superbubble blown by Cyg OB2. Our work indicates that the past dilemma regarding the gamma-ray line emission from Cygnus resulted from an overestimate of the 1809keV flux of the Cygnus complex, combined with an underestimate of the nucleosynthesis yields. Our results illustrate the importance of stellar rotation and SNIb/c in the nucleosynthesis of 26Al and 60Fe. The effects of binarity and metallicity may also be necessary to account for the observations satisfactorily.

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