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Bridging the gap between large and small scales in astronomical images through simultaneous modeling of point-like and diffuse emission

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Many ground- and space-based photometric surveys are quickly approaching sensitivities where correlations between point-like and diffuse emission can lead to significant biases and mis-estimated uncertainties if ignored. Probabilistic cataloging (Portillo et *al.* 2017, Daylan et *al.* 2017) is a Bayesian hierarchical modeling framework where covariances due to blending can be explored by sampling from the (transdimensional) model space of catalogs consistent with a given image dataset. In this work, we extend the formalism of probabilistic cataloging to jointly model point-like and diffuse emission through a Fourier component template-based approach, implemented in the code Diffuse Background Cataloger (*DBCAT*). Using a combination of mock and real *Herschel*-SPIRE sub-millimeter multiband map data, we demonstrate that point source and diffuse emission can be reliably separated and estimated, including in the confusion-limited regime. This is validated using catalog- and field-based summary statistics of the reconstructed components. Beyond the set of global Fourier basis templates used by *DBCAT*, additional templates can be included to infer the contributions of unique extended emission components. As an example, we demonstrate that the thermal Sunyaev-Zel'dovich (tSZ) effect can be reliably estimated in cluster fields observed by SPIRE with contamination from cosmic infrared background (CIB) galaxies and cirrus dust, with proper marginalization over a CIB model in which the number of galaxies is unknown *a priori*.

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