The objectives of the IGMultiWave project were:

(i) to predict the multi-wavelength emission from dark matter annihilation and decay as well as from astrophysical sources and processes in the Inner Galaxy in a self-consistent framework spanning radio to gamma-ray energies;

(ii) using state-of-the-art models for known and proposed source populations, to bracket the spectral properties and spatial distribution of their collective emission in the Inner Galaxy;

(iii) to update and improve modeling of the Inner Galaxy environment, including distributions of CR targets and magnetic fields;

(iv) to test the consistency of dark matter models against multi-wavelength observations in the con- text of a detailed, self-consistent, and complete model of the Inner Galaxy emission.

The work performed since the beginning of the project directly addresses objectives (i) and (iv), and indirectly addresses objectives (ii) and (iii).

The results concerning objectives (i) and (iv) were published earlier this year as "Dark matter implications of the WMAP-Planck Haze" [1]. This publication investigated the consistency of dark matter models which may explain the observed gamma-ray excess from the Galactic Center with multi-wavelength data. A comprehensive library of astrophysical emission models was generated, considering a range of Galactic propagation models and magnetic field configurations. In this work a dark matter source was added to the publicly-available code package GALPROP, and was then used to generate dark matter emission models. Significant additional work, not specified in the proposal, was done to evaluate the impact of microwave Bubbles (a counterpart to the Fermi Bubbles in gamma rays which was recently characterized more fully in the Planck data, and is not expected to be associated with a dark matter signal) on the results of the template fit, including the investigation of possible degeneracies with a dark matter component, and the implications of the analysis for dark matter. The main result of the work is that Planck and WMAP data are consistent with a dark matter interpretation of the gamma-ray excess (Fig. 1), however strong degeneracies between a dark matter component and the Bubbles exist in the microwave data (Fig. 2), and a clear and robust detection of dark matter in the Inner Galaxy using the microwave data is currently not possible.

Given these findings, further characterization of the multi-wavelength properties of Galactic sources (objective (ii)) and improvements in modeling the environment of the Inner Galaxy (objective (iii)) were not pursued given the unanticipated challenges to performing sensitive dark matter searches with multiwavelength Inner Galaxy data introduced by the Bubbles. Alternative studies to support the goal of sensitive particle dark matter searches were pursued [2–7]. Several of these studies set competitive limits on dark matter annihilation in different targets [2, 5, 6], while two focused on future prospects for indirect searches [4, 7], and one placed new, strong constraints on the decay of sterile neutrino dark matter [3].

The modifications to the GALPROP code to introduce a dark matter source, used in [1],were made publicly available at `https://github.com/a-e-egorov/GALPROP_DM`.

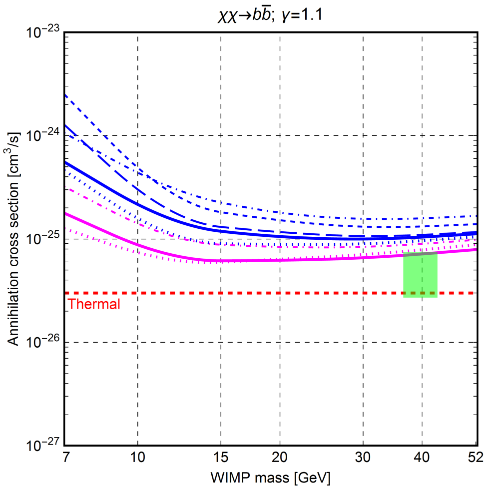


Figure 1: Upper bounds on dark matter annihilation cross section as a function of dark matter particle mass, for annihilation to $b\bar{b}$, assuming a density profile with $\gamma = 1.1$. The green shaded region marks models that can explain the observed gamma-ray excess. From [1].

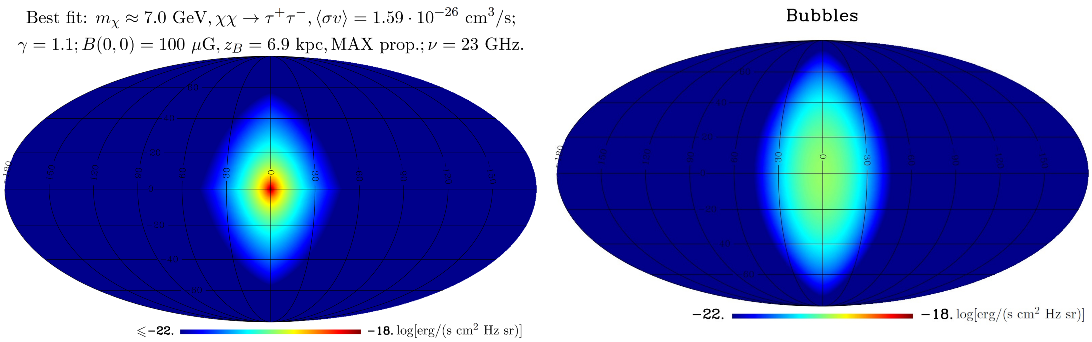


Figure 2: Sky maps of emission from the best-fit dark matter model (left) and from the Bubbles (right). The morphology of the emission is very similar, making these two components strongly degenerate. From [1].

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