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AKARI AND SPINNING DUST: INVESTIGATING THE NATURE OF ANOMALOUS MICROWAVE EMISSION VIA INFRARED SURVEYS

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ABSTRACT

Our understanding of dust emission, interaction, and evolution, is evolving. In recent years, electric dipole emission by spinning dust has been suggested to explain the anomalous microwave excess (AME), appearing between 10 and 90 Ghz. The observed frequencies suggest that spinning grains should be on the order of 10nm in size, hinting at polycyclic aromatic hydrocarbon molecules (PAHs). We present data from the AKARI/Infrared Camera (IRC) due to its high sensitivity to the PAH bands. By inspecting the IRC data for a few AME regions, we find a preliminary indication that regions well-fitted by a spinning-dust model have a higher 9 μm than 18 μm intensity vs. non-spinning-dust regions. Ongoing efforts to improve the analysis by using DustEM and including data from the AKARI Far Infrared Surveyor (FIS), IRAS, and Planck High Frequency Instrument (HFI) are described.

Key words: infrared: ISM ? ISM: general ? ISM: dust

1. INTRODUCTION

Emission in the 10 to 90 GHz frequency range was once thought to be explained by a combination of the CMB, synchrotron emission, and free-free emission. As the microwave sky was analyzed more closely, some areas showed a microwave flux higher than was expected from known sources. This excess emission, termed Anomalous Microwave Emission (AME), may be electric dipole emission from small spinning dust grains. This idea is supported by obersvations showing that AME is correlated with dust, and is more tightly correlated in surveys dominated by emission from smaller grains, such as IRAS 25 μm (Ysard et al., 2010). The spinning dust mechanism is supported by theoretical models showing that rapidly rotating grains / molecules with a permanent electric dipole could reproduce the shape of the anomalous continuum SED (Draine & Lazarian, 1998). The models demonstrate that the peak frequency of spinning dust emission depends primarily on 1) How rapidly the molecules are spinning (rotational excitation depends on the frequency of energy of collisions, and 2) The length of the dipole (roughly speaking, the grain / molecule size). The intensity depends on the magnitude of the dipole and the abundance of the carriers. Since the intensity of the AME is very high in many places, the carrier is thought to be abundant. AME is detected in both dense regions such as ρ Ophiuchi and the Perseus Molceular Cloud, as well as in the diffuse ISM. There remains some debate on the exact mechanisms producing AME, and whether or not the AME has a common origin between diffuse and dense ISM regions. Polycyclic Aromatic Hydrocarbon Molecules (PAHs) are a good candidate for the AME / Spinning Dust Emission Carrier. The typical PAH has cross-section of about 10 nm. Given the dust temperature range of the AME regions (16–21 K), the expected size range of PAHs can explain the typical observed AME spectrum. This can be possible however, only if the molecules in question have a permanent electric dipole. Corannulene is one example. Chemically modified symmetric PAHs may also have a permanent electric dipole. The world's only ?all-sky PAH survey? the AKARI Infrared Camera's 9 μm all-sky map demonstrates the abundance of PAHs in the Milky Way (Onaka et al., 2007; Ishihara et al., 2010). We present a preliminary result of an ongoing AME investigation, using the AKARI all-sky map at 9 and 18 μm, the former having uniquely effective coverage of the PAH bands for the entire sky. In this work, we define AME as microwave emission not well-explained by CMB, free-free, syhncrotron, or thermal dust emission sources.

2. AN EARLY IRC vs. AMEσ RESULT AND ONGOING WORK

Figure 1 shows the AME Significance for the AME candidate regions described in Planck Collaboration XV vs. each region's AKARI/IRC 9 to 18 μm intensity ratio. Table 1 gives the results of the circular photometry and the for each region. The total error in the photometry measurement, based on prelinary AKARI/IRC all-sky data, is tentatively estimated at 10%. A 30' radius circular aperture was used for each region, after subtracting an average local background intensity. A trendline is not shown in Figure 1, since AME Significance only shows how well each region's SED is fit by the spinning dust model. Figure one is included to show a general trend. Regions reasonably well explained by spinning dust (AME$\sigma \geq 5$) show a 9/18 μm ratio greater than unity. For AME regions well-explained by a combination of free-free, synchrotron, CMB, and thermal emission (AME$\sigma < 5$), the 9/18 μm ratio tends to be less than unity.

The physical meaning for the enhancement of 9 vs. 18 μm intensity is not clear. However since the 9 μm survey is dominated by the PAH bands, while the 18 μm survey includes primarily thermal continuum contributions from dust grains (rather than PAHs), this may suggest an enhancement of the PAH abundance in spinning dust regions. If this reasoning is correct, it may mean that regions without AME are PAH-poor. Conditions in these regions may be too harsh for PAHs to persist. This would be expected for regions such as M42 which have very intense interstellar radiation fields. M42 (*G209.01-18.90*) was part of this preliminary analysis, and shows a lower 9 to 18 μm ratio. A more complete SED analysis is in progress, using DustEM (Compiègne et al., 2011) and incorporating AKARI/FIS, IRAS, and Planck/HFI data to understand the full range of dust emission. Far infrared data should more robustly reveal how the PAHs are distributed with respect to cooler and larger grain species. A pixel-by-pixel inspection is also underway, using a common resolution of the Planck/HFI 857 Ghz survey (4.7'). The current large-aperture method may overlook AME-relevant spatial variations within complicated regions.

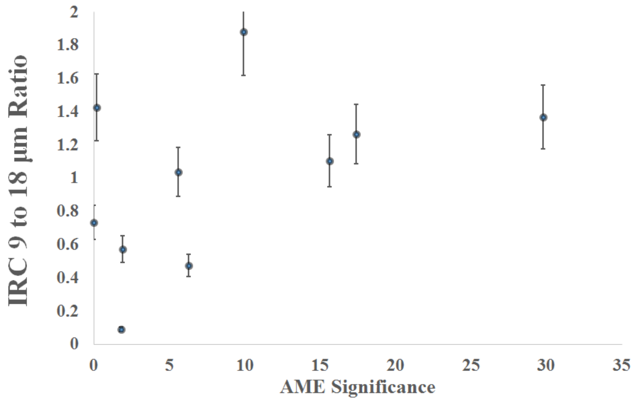

Figure 1. The AKARI/IRC 9 to 18 μm intensity ratios for several AME regions (see Table 1) against each region's AMEσ value, taken from Planck Collaboration XV.

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Table 1
IRC average intensities and 9 to 18 μm band ratios of AME candidate regions

Target	AMEσ[a]	R(9,18)[b]	9 μm MJysr^{-1}	18 μm MJysr^{-1}
G353.05+16.09	29.8	1.37	0.134	0.098
G160.26-18.62	17.4	1.27	0.0186	0.0147
G004.24+18.09	15.6	1.10	0.00254	0.0023
G107.20+05.20	9.9	1.88	0.0955	0.0507
G173.63+02.80	5.6	1.04	0.0244	0.0235
G305.27+00.15	6.3	0.47	0.276	0.583
G209.01-19.38	1.9	0.57	0.0373	0.065
G123.13-06.28	1.8	0.09	0.00753	0.0828
G040.52+02.53	0.2	1.43	0.0596	0.0418
G289.80-01.15	0	0.73	0.0887	0.121

[a] AME sigma levels from Planck Collaboration XV.
[b] the AKARI 9 to 18 μm ratio.

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