Organic Matter in Space
Proceedings IAU Symposium No. 251, 2008
S.L.Kwok, S.Sandford, eds.

DOI: 00.0000/X000000000000000X

ISM Spectrum by Cosmic Dust?

Thomas V. Prevenslik

Discovery Bay, Hong Kong
email: thomas.prevenslik@gmail.com

Abstract. Currently, the interstellar medium (ISM) spectrum extending from the visible (VIS) to the far infrared (FIR) is explained by the response of dust particles (DPs) to the ultraviolet (UV) radiation in the thermal blackbody (BB) emission from nearby stars. The extended red emission (ERE) is the UV excited photoluminescence (PL) of chemical compounds carried by the DPs; whereas, the unidentified infrared (UIR) bands are BB thermal emission from DPs heated by the absorption of UV photons to temperatures from 30 - 1000 K. But the ISM spectrum is a broadband continuum consistent with non-thermal sources of electromagnetic (EM) radiation, and not discrete UV excitations. In this paper, the DPs comprising both nanoparticles (NPs) and microparticles (MPs) produce the broadband ISM continuum by the quantum electrodynamics (QED) confinement of CMB radiation. The broadband ISM continuum then as the EM radiation source excites chemical species carried by the DPs to produce spectral lines including the ERE while the UIR bands are produced directly in DPs without an increase in temperature, the DPs always remaining at 2.7 K. By Mie theory, the DPs partially absorb CMB radiation that is promptly suppressed under QED confinement. But the suppressed CMB radiation cannot be conserved by an increase in DP temperature because the Einstein specific heat already very low at 2.7 K vanishes at typical EM confinement frequencies. Since the EM confinement frequency is the lowest frequency allowed in the DPs by QED, the absorbed CMB radiation depending on the DP diameter is conserved by the emission of FIR to VIS radiation. In this way, the ISM spectrum is inextricably linked to CMB radiation through an uncountable number of Mie absorptions and QED induced emissions in cosmic dust.

Keywords. ISM,CMB,dust,QED,non-thermal EM radiation

---

1. Introduction

The ISM spectrum has been linked to DPs (Li 2004) and usually interpreted to be one where UV radiation from nearby stars: (1) excites inorganic and organic chemical species carried by DPs to produce ERE in silicon NPs (Witt et al. 1998) and (Smith & Witt 2002), and (2) heats carbon grains to temperatures 30-1000 K from which thermal BB emission produces the UIR bands (Li & Draine 2001). However, it is unlikely any combination of UV radiations, chemical species, and DP geometries necessary to duplicate the broadband ISM spectrum will be unique. It may be better to derive the ISM spectrum assuming only that DPs and CMB radiation permeate the ISM (Hauser & Dwek 2001). It is therefore hypothesized:

The DPs produce the ISM spectrum from CMB radiation

and assuming the DPs had specific heat over the millennia is consistent with (Hoyle & Wickramasinge 1967) that DPs on an intergalactic scale thermalized much of the radiation produced by galaxies over past 10^{10}years. Absent specific heat, however, the DPs do not thermalize radiation, and instead are shown here to produce the VIS and IR radiation we know as the ISM spectrum.

2. Theory and Analysis

Although CMB radiation at about 160.4 MHz lacks the Planck energy to produce VIS photons, the ISM spectrum may be explained if the DPs induce the CMB radiation to undergo frequency up-conversion to VIS levels. One such non-thermal process is QED induced EM radiation (Prevenslik 2004). Finding analogy with creating photons of wavelength λ by supplying EM energy to a quantum mechanical box having walls separated by $\lambda/2$, the DPs produce high Planck energy QED photons. In this regard, it has been known for some time (Mie 1908) that low frequency EM radiation having half-wavelength radiation long in relation to the DP diameter is partially absorbed by the DP.

Moreover, if the DP is absent specific heat, the absorbed CMB radiation cannot be conserved by an increase in temperature (Prevenslik 2004). Instead, conservation proceeds by QED induced frequency up-conversion to the EM confinement frequency of the DP, thereby inducing the emission of EM radiation at FIR to VIS frequencies.

But Mie absorption efficiency is low in single interactions between DPs and CMB radiation. The ISM spectrum therefore relies on multiple Mie absorptions and QED emissions among DPs in a continuous size distribution, each interaction successively increasing the frequency to produce the ISM spectrum at near unity Mie absorption efficiency.

EM Confinement Frequency The EM confinement frequency f is a statement of the boundary conditions imposed on the absorbed CMB photon by the DP. The DPs are taken to be spherical of diameter D (=2R) depicted in Fig. 1.

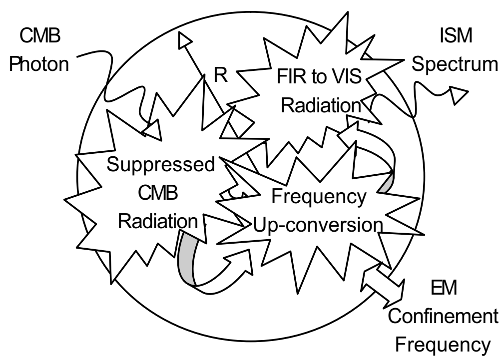

Figure 1 QED Induced CMB Radiation in DPs

The Planck energy E_P and wavelength λ_{EM} under EM confinement of the absorbed CMB photon are,

$$E_P = \frac{hc}{\lambda_{EM}} \; ; \; \lambda_{EM} = 2Dn_r \; ; \; f = \frac{c}{\lambda_{EM}} \tag{2.1}$$

where, h is Planck's constant, c is the speed of light, and n_r is the NP refractive index.

Mie Absorption Efficiency The Mie absorption Q_{abs} efficiency for DPs smaller than the CMB wavelength λ is given by (Bohren & Huffman 1983),

$$Q_{abs} = 4XIm\left(\frac{m^2-1}{m^2+2}\right) = \frac{24\pi abD/\lambda}{\left(a^2+b^2+2\right)^2+4a^2b^2} \tag{2.2}$$

where, Im means the imaginary part, X is the size parameter, $X = 2\pi R/\lambda = \pi D/\lambda$, and m is the DP complex refractive index, $m = a - bi$.

Vanishing Specific Heat In the Einstein specific heat, the vibration of the photons as harmonic oscillators at 2.7 K is shown in Fig. 2(a). Unlike the Debye specific heat, the atoms do not vibrate. Instead, the QED photons oscillate at the EM confinement frequency f as the CMB photon adusts to the DP geometry. Fig. 2(b) depicts the specific heat C* at 2.7 K to vanish for DP diameters $D = \lambda\ /2 < 250$ microns.

Modified Stefan-Boltzmann Equation The classical Stefan-Boltzmann (SB) equation for radiative heat transfer assumes unity Q_{abs},

$$\frac{Q_{SB}}{A} = \sigma\left(T_{BB}^{4} - T^{4}\right) \tag{2.3}$$

where, σ is the SB constant, A is DP area, and T and T_{BB} are the temperatures of the DP and BB surroundings. Beyond excluding Mie absorption efficiency, the SB equation assumes the DP has specific heat to conserve the absorbed BB radiation by an increase in temperature T. But DP specific heat vanishes, and therefore DPs may only conserve absorbed CMB radiation by the emission of QED induced EM radiation. The modified SB equation,

$$Q_{SB} = \sigma A Q_{abs} T_{BB}^{4} - E_{p}\frac{dN_{p}}{dt} \tag{2.4}$$

where, dN_P/dt is the rate of QED induced photons having Planck energy E_P. At steady state, the absorbed BB radiation produces EM radiation. The QED photon rate,

$$\frac{dN_P}{dt} = \frac{\sigma A Q_{abs} T_{BB}^{4}}{E_P} = \frac{2\pi\sigma T_o^4 D^3}{hc} Q_{abs} \tag{2.5}$$

QED Induced ISM Spectrum In a single interaction of CMB radiation with a DP, the Mie absorption efficiency is very low ($Q_{abs} << 1$). But the Q_{abs} efficiency may approach unity by multiple interactions in the continuous ISM mix of NPs and MPs. Fig. 2(c)shows how multiple interactions tend to maintain unity Mie efficiency ($Q_{abs} = 1$) in successive Mie absorptions and QED emissions. For aluminum and metal oxide DPs, the reduction of the CMB wavelength from 1870 to the VIS at 0.3 microns takes about 10 interactions. E.g., CMB radiation interacting with 100 micron MPs produces 550 micron FIR, the FIR at 550 micron then produces FIR at 160 microns in 30 micron MPs, and so forth until NPs at 0.6 micron produce the VIS photons.

For unity refractive index n_r and Mie efficiency Q_{abs}, the QED photons having Planck energy E_P and production rate dN_P/dt are shown in Fig. 2(d). One 0.2 micron UV photon is produced every 10 seconds in 0.1 micron diameter NPs while 2 - 0.6 micron red ERE photons per second are produced in 0.3 micron NPs. The UIR band is produced in a continuum beginning with 600 - 3.3 micron IR photons per second in 1.65 micron MPs and ending with 30,000 - 12 micron IR photons per second produced in 6 micron MPs.

3. Discussion

Historically, DPs having an entire heat capacity comparable to the Planck energy of the single UV photon were thought to cause large temperature fluctuations (Purcell 1976) and even more recently, the UIR bands have been explained (Draine & Li 2001) by temperature increases of 30-1000 K upon heating by UV photons. The findings here differ in that non-thermal QED induced EM radiation produces both the ERE and UIR bands without the DPs increasing in temperature. Moreover, temperature fluctuations to produce the UIR bands by thermal emission are highly unlikely because the DP specific heats already low at 2.7 K vanish at high EM confinement frequencies.

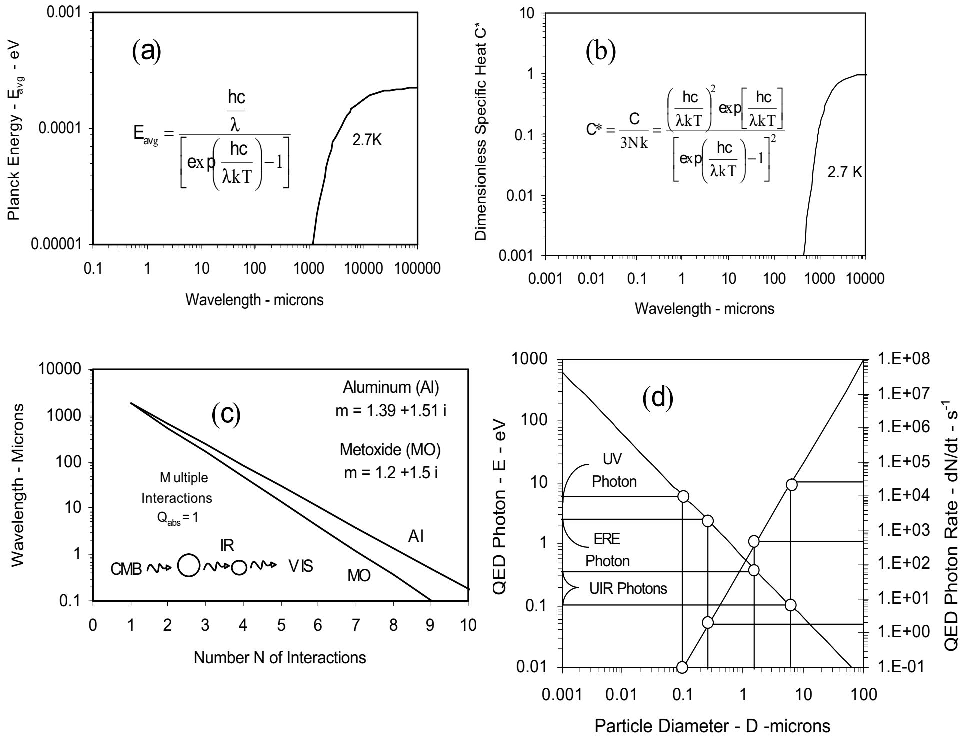

Figure 2 QED Induced CMB Radiation and the ISM Spectrum

4. Conclusions

The ISM spectrum is produced by QED induced EM radiation from the multiple interactions of a continuum of DP sizes. DPs always remain at 2.7 K. Indeed, UV radiation from nearby stars is not necessary to produce the ERE by PL of chemical species, or the UIR bands by heating to temperatures of 30 - 1000 K.

Further study is directed to DP size distributions that duplicate the broadband ISM continuum. Chemical species carried by the DPs and excited by the ISM continuum then combine in the total ISM spectrum as spectral lines superposed on the ISM continuum.

References

Bohren, C.F., & Huffman, D.R. 1983, *Absorption and Scattering of Light by Small Particles*, J. Wiley & Sons, New York
Draine, B.T., & Lee, A. 2001, *ApJ*, 647,676
Hauser, M.G., & Dwek, E. 2001, *Ann. Rev. Astron. Astrophys.*,39, 249
Hoyle,F. & Wickramasinghe, N.C. 2001, *Nature*, 214,969
Li, A. 2001, *Astrophysics of Dust*, ASP Conference Series, 309,417
Draine, B.T., & Li, A. 2001, *ApJ*, 554,778
Mie, G. 1908, *Ann. Phys.*, 330, 337
Prevenslik, T.V., 2004, *www.geocities.com/thomas_prevenslik*
Purcell, E. M. 1976, *ApJ*, 206, 685
Smith, T.L., & Witt, A. N. 2002, *ApJ*, 565,304
Witt, A. N. 1999, *JGR*,105(A5), 10299
Witt, A. N., Gordon, K. D., & Furton, D.G. 1998, *ApJ*, 501, L111.