Molecules mixture model to explain the nature of interstellar matter

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Abstract

The nature of interstellar matter has been explained by presenting a model consists of organic and inorganic materials mixture in the wavelength range (9-12) µm.

Laboratory samples of different concentrations of these materials were prepared and examined by using FTIR spectrometer device. Results of spectra for these samples are compared with observation of Trapezium nebula in the same wavelengths range. The best mixture model found to fit with observation is a sample consists of:11.96 % (Diatom silica (98% pure silica)) + 14.35 % (Carbon (C)) +27.63 % (Tryptophan amino acid) + 46.06 % (Tyrosine amino acid), this are done using convolution technique. Interstellar matter could be explained biologically, as the contribution of organic material is almost 88%.

Keyword: interstellar matter, interstellar extinction curve, spectroscopy, convolution.

نموذج خليط الجزيئات لتفسير طبيعة المادة بين النجوم

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الخلاصة:

تم تفسير طبيعة المادة بين النجوم من خلال تقديم موديل يحتوي على خليط من مواد عضوية ولا عضوية لمديات الطول الموجي µm (9–12). نماذج مختبرية لتراكيز مختلفة تم تحضيرها وفحصها بواسطة جهاز (FTIR spectrometer). نتائج الاطياف المستحصلة لهذه النماذج تمت مقارنتها مع الطيف الرصدي لسديم المعين (Trapezium nebula) لنفس مديات الطول الموجي .وجد بان افضل موديل تطابقي مع الطيف الرصدي يتكون من خليط يحتوي على: 11.96 % (Diatom silica (98% pure silica)) + 14.35 % (Carbon (C)) +27.63 % (Tryptophan amino acid) + 46.06 % (Tyrosine amino acid). تم اجراء التطابق باستخدام تقنية الالتفاف (convolution) وان المادة بين النجوم يمكن تفسيرها بايولوجيا وذلك لمساهمة المواد العضوية فيها بنسبة تساوي تقريبا 88%.

Introduction

The extinction of starlight is caused by the absorbance and scattering of energy by the solid material in the interstellar matter region. The degree and wavelength dependence of the interstellar extinction curve is affected by the grain size, composition, and morphology of the dust between the source of the starlight and the observer [1].

The precise chemical composition of interstellar matter (IM) dust grains remains an unsolved problem in astrophysics. Astronomers tried through these investigations to identify the chemical composition of IM, through two principle methods, these are [2]:

1. Modeling of the broadband extinction and polarization curve using Mie theory.

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2. Identification of discrete spectral features attributed to grain materials using infrared, visual and ultraviolet spectroscopic techniques.

The study of interstellar dust has led to several dust models that are compared with the average extinction curve obtained from observations of stars through interstellar clouds.The extinction curve is separates the light spectrum into three parts: Infrared –visible; Ultraviolet (hump signature at 2200 Å hump), and the far- Ultraviolet region [3].

Interstellar dust models

Since early thirties of twenty century till now, many astronomers have suggested different models to explain IM extinction curve .Inorganic; organic; and mixed material of both. In 1935, Lindblad suggested that ices would form in IM by random accretionof ice nucleation [4] .Oort and Van de Hulst, in 1946, suggested a dirty ice model consisting of saturated molecules such as H_2O, CH_4, and NH_3 [5].

In 1954, Cayrel and Schatzman suggested that graphite grain comprising a small component of the total mass of IM, could account for the observed polarization to-extinction ratio because of their strong optical anisotropy [6-7].Gaustad, in 1963, assumed that the 8-12µm band of several cool stars was referred to mineral silicates mixture like ($MgSiO_3$, SiO_2 and Fe_2O_3) [8] .While Woolf & Ney, in 1969, referred the emission in M-superginets at the 10-14 µm region to silicate particles such as Olivine (Mg, Fe) SiO_4 [9].

Hoyle and Wickramasinghe, in 1969 and 1970, suggested models contain a mixture of silicates and graphite (graphite-(ice-coated) - silicate mixture) [10-12].

The observations of the 8-13 µm spectrum of IRS 5in W3 which is presented in 1973 by Aitken and Jones, indicating that it is a luminous object suffering a large extinction by an extended dust cloud. It gives new evidence for the presence of large quantities of cool silicate-like grains in compact H II regions [13].

In 1974, Wickramasinghe, presented a model consist of mixture of organic and inorganic materials. He assumed that interstellar grains consist of a mixture of small graphiteand silicate particles coated by organic polymeric mantles [14].

Hoyle and Wickramasinghe, in 1977, found that the infrared spectrum of OH 26.5 + 0.6 over the waveband 2-40 µm is explained in terms of a polysaccharide grain model. This was very close between theory and observation for the identification of interstellar polysaccharides [15].

In 1980, Hoyle, Wickramasinghe and Jabir represented models of three main types of grain of biogenic origin (bacterial grains of radius 1/3µm;Graphite-spheres of radius a = 0.02 µm, and Dielectric spheres of radius 0.04 µm [16-18].

Al-mufti et al., in 1982, produced spectrum of laboratory sample reassembled the extinction in the near UV- region.The sample consist of a mixed culture of diatoms – organo – siliceous polymers [19-20].

Karim et al., in 1983, discovered the broad band interstellar absorption feature centered on 2800 Å in the extinction curve of starlight confirms the presence of proteinaceous material in grains .This feature is responsible for the presence of microorganisms in IM for stars showing abnormally low graphite absorption [21].

Organic and inorganic molecules, then after became a reality presence in IM, as many researcher announced in their work (e.g.: Leger and Puget[22] ; Hoyle et al.[23-24] ; Jabir et al.[25] ;Willems[26];Majeed et al.[27-28]; Jazbi et al.[29] ; Hoyle and Wickramasinghe [30-31] ;Al –Qazzaz et al.[32] ;Clayton et al.[33];Whittet et al.[34]).

Recent work confirming the presence of polycyclic Aromatic Hydrocarbons (PAH) through a model presented by Muthumariappan in 2010,comprising silicate, graphite and PAH applied to the extinction curves explaining interstellar dust grains [35].Debroy and das in 2011 presented a model comprised of silicate –graphite mixture to explain the interstellar extinction curve in the IR – range (0.11-3.4)µm [36].

Steglich et al., in 2012, concluded that the UV-visible absorption curves of PAH mixtures can be very smooth, displaying no sharp bands, if the molecular diversityis sufficiently high. [37].

It is obviously seen from the above review, that interstellar matter could be explained by different ratios values mixture of inorganic – organic molecules using different techniques as well as theoretical one, for matching with observation results taken different early stars through IM.

This work willing adopt laboratory investigation, experimenting several mixtures of available organic and inorganic materials using IR-UV in the range (9-12) µm wavelength, and treating results using convolution technique

Experimental work of parts

The following apparatus has been used:

1- Mortar. 2- Mini hand press.3-Sensitve balances .4- Oven. 5-Fourier transforms infrared spectroscopy (FTIR)device.

Material used

Inorganic and biological materials were used as follow:

a- Inorganic materials:

including: Silicon dioxide (SiO_2), Magnesium oxide (MgO),Iron (III) oxide or ferric oxide (Fe_2O_3), Carbon (C) and Diatom silica (98% pure silica).

b- Biological materials:

including: Tyrosine amino acid, Glycine amino acid and Tryptophanamino acid

Sample preparation

Every materiel mixed with KBr at mass ratio 1/10 to make the samples. The samples were kept in the oven for 12 hours at a temperature of (80 K° - 90 K°) to get rid of the humidity and keep it dry. The samples were pressed by Mini hand press to produce the disks. Each disk examined by FTIR spectrophotometer device to measure the transmittance as a function of wave number of each material. Spectra were produced and further investigation will be applied on these spectra. Spectra sample is illustrated in figure-1.

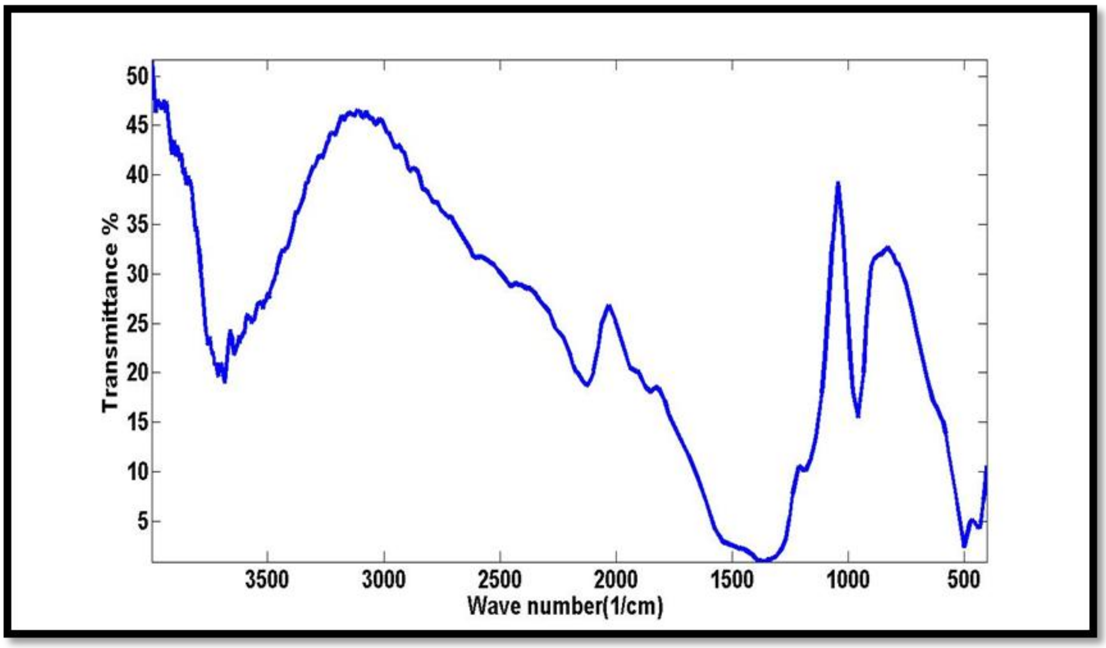

Figure -1: The transmittance (T) produced as a function of wave number in (1/cm) for one of prepared sample (Silicon dioxide (SiO_2)).

Calculations and results:

Experimental measurements produced transmittance (T) which is related to the optical depth $(\tau)$by the equation [32]:

$$(\tau) = -\ln T \text{ .... (1)}$$

This equation used to calculate the optical depth for all experimental results.

The flux density of each sample can be calculated by using the following equation [32]:

$$F(\lambda) = \tau . B(\lambda) . A \text{ .... (2)}$$

Where:

B (λ): Planck function which is given by:

$$B(\lambda) = \frac{2hC^2}{\lambda^5} \times \frac{1}{e^{(hC/\lambda kT)}-1} \text{ ……….. (3)}$$

Where:
h: Planck's constant = 6.63×10^{-27} erg. Sec
C: Light velocity = 3×10^{10} cm .Sec^{-1}
λ: Wavelength in μm
k: Boltzmann's constant = 1.38×10^{-16} erg.k^{-1}
T: Temperature in kelvin(K°)
A: Normalization constant

The flux density as a function of wavelength for all samples has been calculated using the above equations. The experimental data converted into flux density for samples asa function of wavelengths in micrometer in order to fit these data to get the models.

Many tests were done including changing the materials in the mixture and its ratios for many times until achieved a best fit with observation data of Trapezium region. Table 1- is a list of best-fit data obtained matching the observation .

Table 1- Flux density values as function of wavelength for proposed model

Wavelength(μm)	**Flux density (w/cm^2 /s)**
8.60	4.71E-16
8.69	4.87E-16
8.84	5.08E-16
8.97	5.24E-16
9.12	5.34E-16
9.32	5.40E-16
9.45	5.56E-16
9.60	5.64E-16
9.82	5.69E-16
10.00	5.74E-16
10.11	5.76E-16
10.22	5.77E-16
10.31	5.55E-16
10.45	5.35E-16
10.54	5.14E-16
10.69	4.92E-16
10.80	4.69E-16
10.95	4.44E-16
11.06	4.21E-16
11.28	3.97E-16
11.47	3.71E-16
11.78	3.46E-16
11.97	3.21E-16
12.11	2.97E-16
12.27	2.74E-16
12.36	2.49E-16

Figure 2- shows the comparison between the proposed model and observation data for Trapezium region.

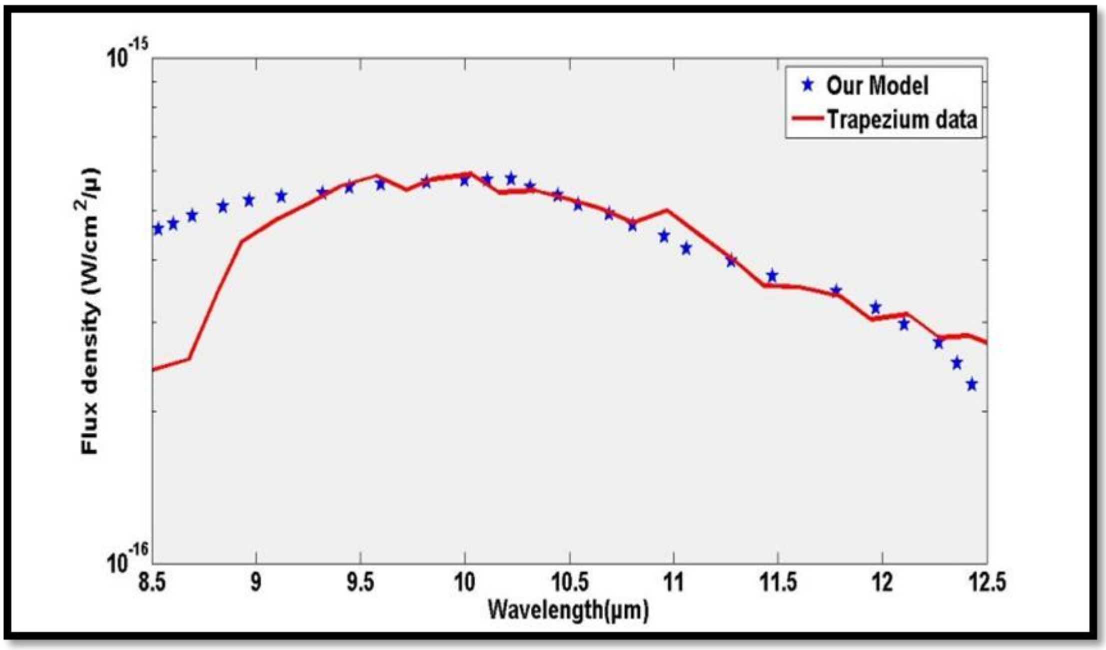

Figure 2- The flux density as a function of wavelength of the proposed model consist of (11.96 % (Diatom silica (98% pure silica)) + 14.35 % (Carbon (C)) +27.63 % (Tryptophan amino acid) + 46.06 % (Tyrosine amino acid))compared with observational data for trapezium region.

This fitting has been done applying the convolution technique, obtaining accurate results for matching with observational data.

Discussion and conclusion

The constituent of interstellar matter could be explained by organic or inorganic or both, by trying different mixture with the achievement of best fitting through wavelength range ,depending on the size nature of interstellar dust grains.

The model proposed in this work found to fit with observation data in the wavelength ranges (9-12) μm, consisting of inorganic and organic materials (chosen from the multi choice trial material) with different percentages contribution used, as shown in table 2.

Table 2- best fit model of inorganic and organic material.

inorganic material	%	organic material	%
1-Diatom silica	11.96	1-Carbon 2-Tryptophan amino-acid 3-Tyrosine amino-acid	14.35 27.63 46.06

This result indicated that the contribution of organic materials represent almost 88% of the sample prepared, the majority of it is the Tyrosine and Tryptophan amino-acids, and Carbon. While inorganic (Diatom silica) contributed only 12% of the sample.

It can conclude therefore, that interstellar matter consists of a huge amount of organic material that biological formation is fairly possible.

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