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Interstellar Extinction in The Galactic Plane

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ABSTRACT

The conceptual boundaries of life are rapidly expanding far beyond the confines of our planet to encompass an ever widening region of the universe. Complex organic molecules in the interstellar dust and comets appear most plausibly to be biologically derived, or at least closely related spectroscopically and structurally to such material.

The aim of this work is to study the nature of interstellar matter throughout galactic plane via comparison of stellar spectrum of reddened and un reddened stars of some spectral classes the galactic plane . Observations of three regions in the galactic plane were adopted via (IUE) and voyager data satellites .These observations are made through wavelength (3.2-10)μm^{-1}.Extinction curve was compared with the microbial model ,the results show good agreement with this curve ,which explains the interstellar matter as a mixture of organic and inorganic particle of different size.

1. Introduction

Twenty five years ago the existence of life outside the Earth was mostly reserved for the realms of science fiction. The standard theory of the origin of life was that due to Haldane(1) and Oparin(2) in which it was proposed that life began in a 'primordial soup' of organic chemicals that developed on a primitive Earth. That theory gained ground after the classic experiments of Miller and Urey(3) where it was shown that organic chemicals that may serve as the building blocks of life could form from suitable mixtures of inorganic gases such a H2O, CH4, NH3 when subjected to electrical discharges or energetic radiation.

The extrapolation from such laboratory experiments to commencement of primitive life involves an assumption that biology is the inevitable end-product of a network of inorganic chemical transformations. The chances of reaching the ultimate goal of life, measured in terms of any sensible criterion involving its intrinsic complexity, must be regarded as being infinitesimally small. Such considerations first led Hoyle and Wickramasinghe(4) to consider extending the Haldane-Oparin primordial soup to an extraterrestrial setting – first to the material of comets in the outer solar system,thence to giant molecular clouds in the galaxy and possibly to even larger systems on a cosmological scale. The discovery of organic molecules in interstellar clouds immediately favoured this progression of steps, although the manner in which organic molecules combined to form a living system against superastronomical odds remained

undefined.

The possibility that under certain conditions there may not be a logical need for an origin of life takes us into the domain of cosmology, favouring some cosmological models over others. At any rate, given the utterly diminutive chances of an origin anywhere there is no need to postulate a multitude of such improbable originations in all the places where life exists, if large scale galactic transfers of microorganisms can be envisioned(5). Such thoughts commended themselves during the early 1980's. At this time a spectroscopic signature of a bacterium was found in interstellar dust, representing the first unequivocal demonstration that over a third of the interstellar carbon in the galaxy was tied up in the form of organic dust grains. Furthermore one could assert that such grains were required to be indistinguishable in their spectral properties from freeze-dried bacteria as indicated, Figure(1)(6).

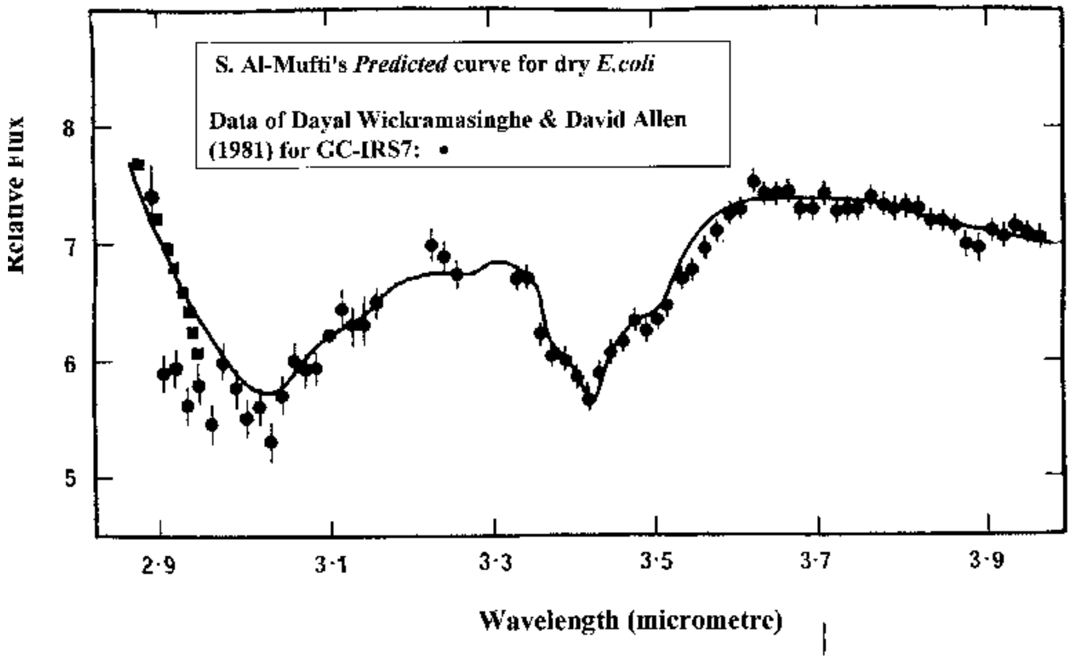

Figure1: Flux From The Galactic Center Source GC-IRS7 (6).

The interstellar medium is generally used to denote the space between the star . interstellar medium contains vast clouds of gas and tiny solid particles, called interstellar matter . Most of this interstellar material is found between the stars in the spiral arms of the Milky Way and other galaxies . The gas and dust is not distributed uniformly in interstellar space , but has irregular distribution, being denser in some areas than in other forming what is called clouds. The interstellar medium contains only 1% as much mass as the stars of the interstellar medium ,99% of the mass is in the form of gas and 1% is in the form of dust . However , this small amount of dust is very efficient at blocking light(7) .

2-1.Interstellar Gas

interstellar gas is distributed generally throughout the regions of the spiral arms of the galaxy. Hydrogen makes up about three quarters of the gas, and hydrogen and helium together compose 99% of it by mass. Interstellar gas creates some spectacular structures in our galaxy , huge glowing clouds heated by stars embedded in them , such as the great Nebula in Orion. Since hydrogen is the main constituent of the interstellar gas , it is often characterize a region of interstellar space according to whether its hydrogen is neutral (H_I region) or ionized (H_{II} region)(8).

2-1-1. H_{II} Region

The gas in H_{II} regions glows by the process of fluorescence . The light emitted from these region of ionized gas consists largely of emission lines, so these gas clouds are called emission nebulae . H_{II} regions have a temperature of approximately 10000k and are heated by the electrons forced by the ionizing Ultraviolet radiation. The liberated electrons collide with atoms around them and speed them up, increasing their energy and thus their temperature(9) .

2-1-2. H_{II} Region

The gas in H_I regions is cold neutral hydrogen atoms with their electrons attached .Cold hydrogen atoms are the most important sources of radio emission, which are radiate at wavelength of 21.11 cm (1421MHz) . This radiation called 21 centimeter radiation, arises by the process of flipping over of the proton spin on the electron spin, due to different orientation of the proton and the electron in the atom(10).

2-2 Molecules in interstellar space.

Optical observations revealed that molecules CN and CH and the radial CH^+ in interstellar space ,and Ultraviolet observations revealed H_2 and CO as well. More than 100 interstellar molecules(9) have been identified so far ,(see table 1) . These include simple molecules like water, ammonia, Silicon monoxide , and hydrogen Sulfide , and such common Organic molecules as formaldehyde, hydrogen cynade, and methyl alcohol. They also include cyanoacetylene and acetaldehyde ,generally regarded as stating points for the formation of the amino acids necessary for living organisms .

The presence of these organic molecules does not, of course , imply the existence of life in space .On the other hand, when we understand the processes by which they are produced , we may have an increased understanding of similar processes which must have preceded the beginnings of the life on the primitive earth some thousands of millions of years ago.

Table (1) : Some interstellar molecules, arranged by number of heavy atoms

0	1	2	3	4	6	8	10	12
H_2	$^{*}CH$	CO CS	HCOOH	$^{*}C_3N$	HC_5N	HC_7N	HC_9N	$HC_{11}N$
	CH^+	$^{*}HCO$	NH_2HCO	$^{*}C_4H$				
	$^{*}OH$	HCO^+ HCS	CH_3CN	HC_3N				
	H_2O	H_2CO H_2CS	CH_3CH_2	CH_3CH_2CN				
	H_2S	CH_3OH H_3SH	CH_3CHO	CH_3OOCH				
	$^{*}CH_4$	NO NS	CH_3CH_2OH	CH_2CHCN				
	NH_3	SO	$(CH_3)_2O$					
		HNO	HNCO HNCS					
		$^{*}CN$ H_2CCO	HCOH					
		HCN NH_2CN	SO_2					
		HNC	OCS					
		CH_2NH	$HOCO^+$					
		CH_3NH_2	HOCN					
		$^{*}C_2H$						
		C_2H_2						
		N_2H^+						
		SiO SiS						
		CO^+						

		C_2						

2-3 Interstellar Dust

Interstellar dust is the second component of interstellar medium and exists in the form of tiny solid dust particles called interstellar grains. Interstellar grains range in size from large molecules to micrometers , the particles are irregularly shaped, and are composed of a mixture of silicates ,iron compounds ,carbon compounds ,and water frozen into ice. Astronomers deduce the presence of these substances from their spectral lines that are seen in star lights that has passed through dense dust clouds(9). It is believed that interstellar dust makes only about 1% of the total interstellar matter . Dust and gas are generally intermixed in space , with their proportions are not everywhere exactly the same . The presence of dust is apparent on many photographs of emission , reflection and dark nebulas.

These nebulae are additional proof that dust exist in space. The tiny solid grains in interstellar space are manifested in the following ways:

- Dark nebulae
- General obscuration
- Reddening of star light
- Reflection of star light
- Polarization of star light
- Infrared radiation
- Interstellar molecules

3. Bacteria: The Space Colonists

"*I always thought the most significant thing that we ever found on the whole goddamn Moon was that little bacteria who came back and lived and nobody ever said shit about it*". — Pete Conrad(11)

On April 20, 1967, the unmanned lunar lander Surveyor 3 landed near Oceanus Procellarum on the surface of the moon. One of the things aboard was a television camera. Two-and-a-half years later, on November 20, 1969, Apollo 12 astronauts Pete Conrad and Alan L. Bean recovered the camera. When NASA scientists examined it back on Earth they were surprised to find specimens of Streptococcus mitis that were still alive. Because of the precautions the astronauts had taken, NASA could be sure that the germs were inside the camera when it was retrieved, so they must have been there before the Surveyor 3 was launched. These bacteria had survived for 31 months in the vacuum of the moon's atmosphere. Perhaps NASA shouldn't have been surprised, because there are other bacteria that thrive under near-vacuum pressure on the earth today. Anyway, we now know that the vacuum of space is not a fatal problem for bacteria.

What about the low temperature and the possible lack of liquid water in space? The bacteria that survived on the moon suffered huge monthly temperature swings and the complete lack of water. Freezing and drying, in the presence of the right protectants, are actually two ways normal bacteria can enter a state of suspended animation. And interestingly, if the right protectants aren't supplied originally, the bacteria that die first supply them for the benefit of the surviving ones! English microbiologist John Postgate discusses this fact in The Outer Reaches of Life(10)

When a population of bacteria dries out without a protectant, many of the cells break open and release their internal contents. Among these contents are proteins, gums and sugars, all of which are protective. If the population is sufficiently dense, so that significant amounts of protectant are released, material released from the majority which died first can protect a few of their surviving fellows.

Comparable considerations apply to death from freezing.... Protective substances such as glycerol are well known and widely used; they are called cryoprotectants. Bacteria frozen without such chemicals leak internal contents, among which are many substances that are cryoprotective.

Postgate says that bacteria have apparently survived for 4,800 years in the brickwork of Peruvian pyramids, and maybe even 300 million years in coal, using the drying strategy. He also describes bacteria that apparently survived for 11,000 years in the gut of a well-preserved mastodon, although in this case the colony may have continued to live and multiply using nutrients available in the carcass. Postgate gives several other examples of long-surviving bacteria, and he is careful to mention the possibility that some of the bacterial cultures may have been contaminated, so not all of the reports are necessarily reliable.

Some bacteria have another even more effective survival strategy: they form spores. Spores are bacterial cells in complete dormancy, with thick protective coats. In terms of our computer analogy, a bacterial spore is like a handheld calculator that has repackaged itself into its original protective shipping carton and turned itself off.

"The resistance of some bacterial cells to environmental destruction is impressive. Some bacteria form resistant cells called endospores. The original cell replicates its chromosome, and one copy becomes surrounded by a durable wall. The outer cell disintegrates, but the endospore it contains survives all sorts of trauma, including lack of nutrients and water, extreme heat or cold, and most poisons. Unfortunately, boiling water is not hot enough to kill most endospores in a reasonable length of time.... Endospores may remain dormant for centuries(13).

4. microbial Model

In late 1970s, Prof. Sir Fred Hoyle and Prof. Chandra Wickramasinghe (14) and Jabir, et al (15) have argued that interstellar grains have a biogenic origin, being generally similar in character to terrestrial microorganisms. They first argued that interstellar extinction data over the visual waveband could be explained with remarkable precision by terrestrially determined size distribution of space forming bacteria, provided account is taken of the evacuation of free water under interstellar condition. Later proposed that interstellar grains are distributed between three main classes of particles (16).

1- Bacterial grains in the form of long hollow needles with cavities due to evacuation of water. The average refractive index (m) has been taken to be m=n-ik, where n is equal to 1.149, 1.16 and 1.167 and k is varied in the range 0.0 To 0.25 with mean radius=1/3 μm.

2- Graphite spherical particles of mean radius 0.02μm and complex refractive index is wavelength dependent.

3- Small dielectric spheres, of radius 0.04μm, and complex refractive index varied with wavelength.

In the three-component model the smaller dielectric component was identified with mycoplasmas and the graphite spheres were taken to be degraded bacterial cells (17).

Jabir, et al (16) have used this model and the Mie formulae to compute the extinction properties of the spherical grain species of component 2 and 3 and the corresponding formulae for infinite cylinders to compute the properties of cylindrical bacterial grains species of component 1.

The combined extinction behavior of the three component model were calculated according to the expression (10):

$$Q(\lambda) = \frac{Q_{ext}^{(1)}(\lambda)}{Q_{ext}^{(1)}(\lambda_o)} + wg\,\frac{Q_{ext}^{(2)}(\lambda)}{Q_{ext}^{(2)}(\lambda_\circ)} + wd\,\frac{Q_{ext}^{(3)}(\lambda)}{Q_{ext}^{(3)}(\lambda_\circ)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where $\lambda_\circ = 1.8\,\mu\mathrm{m}^{-1}$ and **wg** and **wd** are the weighting parameters specified such that the contribution from individual species to the extinction at $\lambda^{-1} = 1.8\,\mu\mathrm{m}^{-1}$ are in the ratio:

Hollow needle(1):graphite(2):dielectric spheres(3)

1.0 : wg : wd………..(2)

The total extinction coefficient calculated from equation (1) and then normalized to obtain:

$$\frac{E_{(\lambda - v)}}{E_{(B - v)}} = A + BQ(u) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where A and B are two normalization factors chosen so as to give two specified values of normalized extinction two specific wavelengths.

5. Results and Discussion

Fig (2) ,(4) and (6) shows plots of observed normalized extinction data for σSco , ξPer and ςOph fitted with microbial model of interstellar dust grains that obtained by using Mie formula to compute the extinction properties of the spherical grain species of both graphite and dielectric spheres and corresponding formulae for infinite cylinders to compute the properties of cylindrical bacterial grains species.

It was found here that the best fit between σSco observational data and microbial model was for m_1 =1.16-0.015i of long hollow needle shape bacteria with mean radius 0.33µm, as shown in fig.(2).

From studying Graphite spheres of mean refractive index m_2=n-ik, radius 0.02µm and dielectric particle grains of mean refractive index m_3=1.5-0.0i , mean radius 0.04 µm, the refractive indices of the spherical graphite grains were varied with wavelength. The relative proportion of three component bacterial model i.e. hollow needle: graphite: dielectric spheres are defined as wb : wg : wd : and the contributions of each component are in the ratio 1.0 : 0.2 : 0.02 respectively , normalization is to

$$\Delta m= 3 \quad \text{at} \quad \lambda^{-1} = 3.8\ \mu m^{-1}$$

$$\Delta m= 5 \quad \text{at} \quad \lambda^{-1} = 10\ \mu m^{-1}$$

And for ξPer It was found here that the best fit between observational data and microbial model was for m_1 =1.16-0.015i of long hollow needle shape bacteria with mean radius 0.33µm, as shown in fig.(4). From studying Graphite spheres of mean refractive index m_2=n-ik, radius 0.02µm and dielectric particle grains of mean refractive index m_3=1.5-0.0i , mean radius 0.04 µm, the refractive indices of the spherical graphite grains were varied with wavelength. The relative proportion of three component bacterial model i.e. hollow needle: graphite: dielectric spheres are defined as wb : wg : wd : and the contributions of each component are in the ratio 1.0 :0.081:0.02 respectively , normalization is to

$$\Delta m= 3 \quad \text{at} \quad \lambda^{-1} = 3.6\ \mu m^{-1}$$

$$\Delta m = 7 \quad \text{at} \quad \lambda^{-1} = 9\ \mu m^{-1}$$

And for ςOph It was found here that the best fit between observational data and microbial model was for m_1 =1.16-0.015i of long hollow needle shape bacteria with mean radius 0.33µm, as shown in fig.(6). From studying Graphite spheres of mean refractive index m_2=n-ik, radius 0.02µm and dielectric particle grains of mean refractive index m_3=1.5-0.0i , mean radius 0.04 µm, the refractive indices of the spherical graphite grains were varied with wavelength. The relative proportion of three component bacterial model i.e. hollow needle: graphite: dielectric spheres are defined as wb : wg : wd : and the contributions of each component are in the ratio 1.0 :0.01:0.02 respectively , normalization is to

$$\Delta m = 4.5 \ \text{at} \ \lambda^{-1} = 4\ \mu m^{-1}$$

$$\Delta m = 9.5 \ \text{at} \ \lambda^{-1} = 8.6\ \mu m^{-1}$$

From fig, (2), (4) and (6) it is obvious that there is a very close agreement between the observed extinction and microbial model, With some simple differences because of disuniform distribution of grains and the differences in the density and volume of grains .

6-Conclusions

The results show that terrestrial bacteria hypothetically freeze-dried under interstellar condition have optical properties that are similar to interstellar dust grains

The 2175A^o interstellar absorption feature, is due to the degradation of biological material to carbon which causes a strong absorption in star light.

Computation of the detailed optical properties of σSco , ξPer and ςOph over the waveband $3.2\mu m^{-1} \leq \lambda^{-1} \leq 10\ \mu m^{-1}$ for three biologically derived components of this model is shown to be in excellent agreement with the observational data of interstellar dust.

From the comparison of our result with the result taken from Assaf (18) .It is clear that our model is much better than that obtained by them, as shown in fig.(2),(4) and (6).

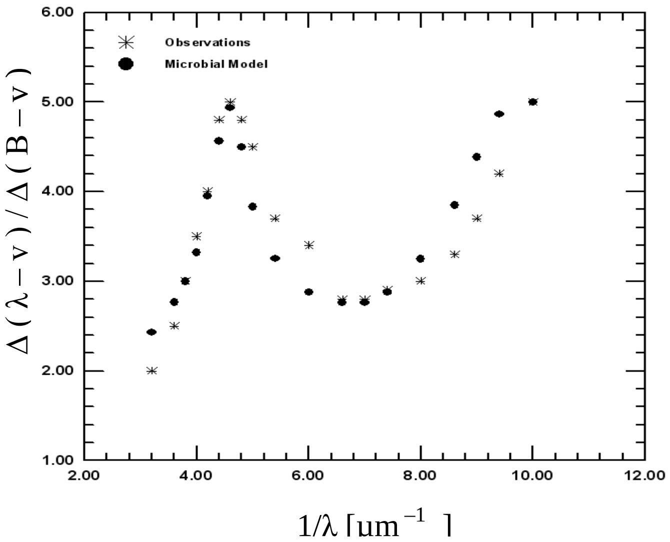

Figure 2: The Normalized Extinction Curve For σSco Fitted with Microbial Model.

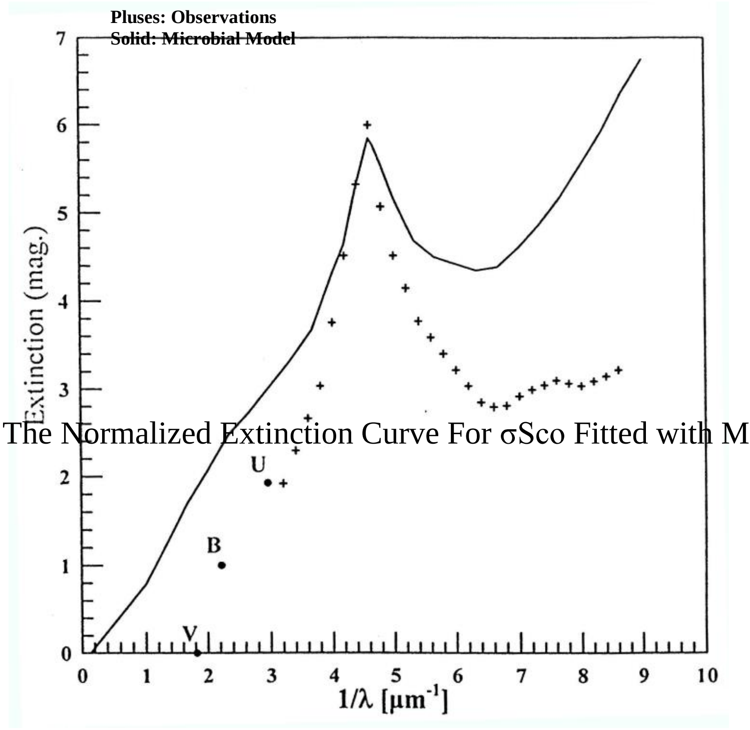

Figure 3: The Normalized Extinction Curve For σSco Fitted with Microbial Model(18).

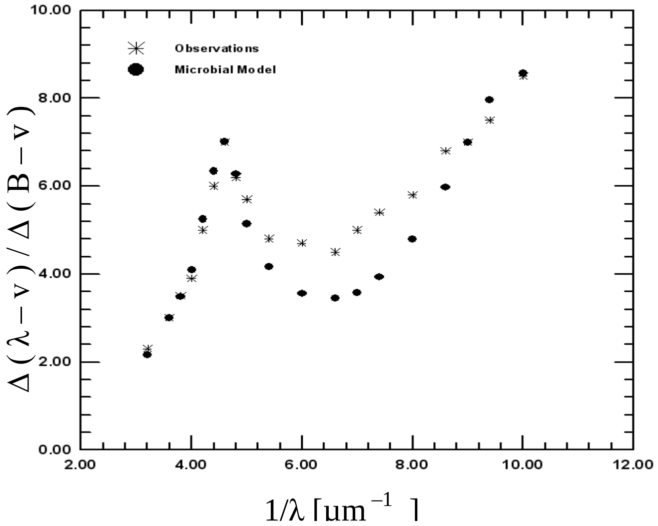

Figure 4: The Normalized Extinction Curve For ξPer Fitted with Microbial Model.

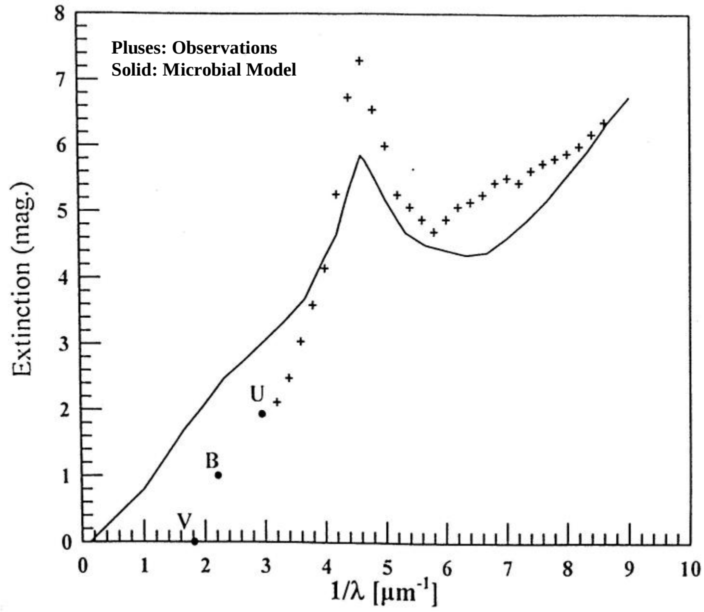

Figure 5: The Normalized Extinction Curve For ξPer Fitted with Microbial Model(18).

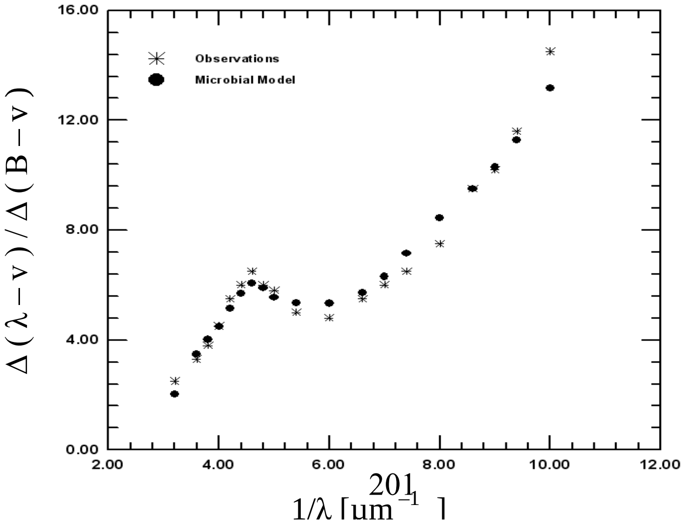

Figure 6: The Normalized Extinction Curve For ςOph Fitted with Microbial Model.

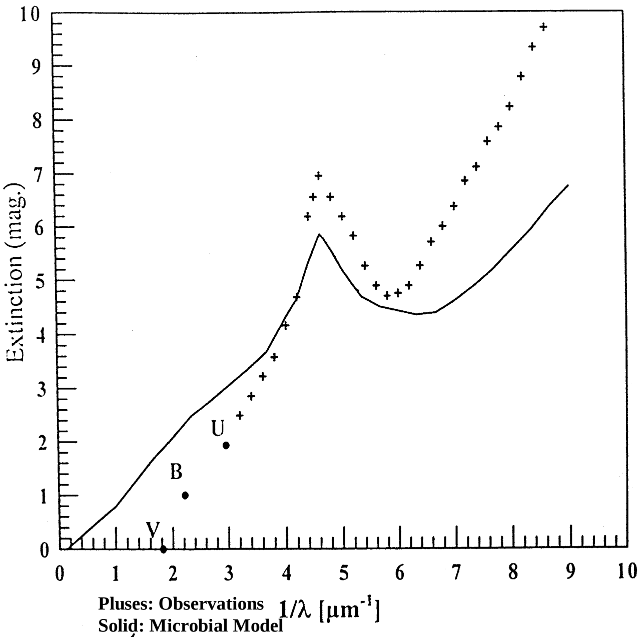

Figure 7: The Normalized Extinction Curve For ςOph Fitted with Microbial Model(18).

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