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Nano-metric Dust Particles as a Hardly Detectable Component of the Interplanetary Dust Cloud

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Abstract. The present work introduces the hypothesis of existence of a hardly detectable component of the interplanetary dust cloud and demonstrates that such a component is a dust formation consisting of the dust particles of nano-metric dimensions. This work describes the main physical properties of such a kind of nano-dust, and its possible chemical and mineralogical peculiarities proposes new explanations related to reddening of the dynamically cold transneptunian objects on account of scattering their light by nano-dust of the hardly detectable component of the interplanetary dust cloud. We propose the relation for the coefficient of absorption by the nano-dust and provide results of the statistical analysis of the TNO color index–orbital inclinations. We also present a critical assessment of the proposed hypothesis.

Key words. Nano-dust particle—interplanetary dust—zodiacal light—scattering—transneptunian objects.

1. Introduction

It is known that a dust and a gas form the main part of interplanetary substance. The origin of the interplanetary dust still remains a subject of scientific interest and is widely discussed. The most common views with respect to this include the following: (1) formation of the interplanetary dust as a result of destruction of comets and asteroids, and collisions in the Kuiper belt (Backman 1997; Levasseur-Regourd *et al.* 2007; Mann *et al.* 2010); (2) formation of the dust during one of the stages of formation of the solar system after the phase of the proto-planetary disk (Greaves *et al.* 2005; Raymond *et al.* 2005; Wang *et al.* 2006). A theory developed within the scope of the first approach, implies a long-term ongoing process of formation of the dust particles. In other words, all the new comets and asteroids, in the course of destruction, produce new masses of the dust matter and at the same time, fill the space of the solar system with different disperse dust particles of various chemical and mineralogical composition.

The second approach implies existence of a certain relict dust matter – the oldest remains of a complex and a multistage path of formation of the solar system and first of all, of its planetary component. Keeping in mind the development of other views as well, we may assume that the first and the second approaches may not contradict but to some extent even complement each other.

It is not difficult to assume that the relict dust may be continuously enriched by modern dust matter – a product destruction of the comets and asteroids. However, the solar radiation sharply limits a possibility of existence of the relict dust. While evolving and becoming smaller in size, the dust particles will be swept out as a result of the solar radiation pressure, or fall on the Sun – the 'Poynting–Robertson effect'. Therefore, the dust of the interplanetary dust cloud is relatively young and constantly renewable.

Based upon the several centuries-long observed features of phenomena of the zodiacal light, general ideas regarding the interplanetary dust cloud have been developed (Cassini 1730; Krick *et al.* 2012; Nesvorný *et al.* 2010). This lenticular or disc-shaped dust formation in a form of the cloud of the different dispersed dust particles, is located on the ecliptic plane and has, respectively, the corresponding physical parameters: diameter, mass, spatial density and symmetry. The phenomenon of the zodiacal light is preconditioned by scattering the sunlight of the dust cloud.

According to the current assessment, sizes of a single dust particle – a component of the cloud, are varied within the 10–100 mkm range (Backman 1997). In our view, destruction of comets and asteroids, collisional processes and sublimation of the dust, may initiate formation of the dust particles of submicron sizes, including dust particles of nano-metric sizes.

Passage by the periodic and non-periodic comets of the perihelion of their orbits, which is accompanied by an intensive gas and dust release, may also serve as an 'instrument' for filling the interplanetary dust cloud with the dust particles of nano-metric sizes. Despite a possible sweep out of dust through the solar radiative pressure, its permanent filling will take place on account of the constant destruction of small bodies and a regular passage of comets near the Sun.

Therefore, the interplanetary dust cloud may contain an unknown, hardly detectable component in the form of a cloud-like formation consisting of dust particles of nano-metric sizes. In other words, a rather high amount of dust may exist in those areas, where their presence was not assumed previously.

The present paper is devoted to the basic physical and chemical characteristics of such kinds of nano-dust.

2. Nano-dust as a hardly detectable component of the interplanetary dust cloud

It is known that the zodiacal cloud located in the ecliptic plane consists of the dust particles, which are from several up to 100 microns in diameter (section). A series of works are devoted to studying of sizes, shapes and spatial distribution of such particles in the interplanetary dust cloud. Release of dusts out of the comets, collisions of the asteroids and of the objects of the Kuiper belt, and some other events ensure production of more and more new dusts.

The evolutionary path may be different for each single dust particle, however, at the final stage of evolution, all particles will be necessarily reduced in sizes (sections).

The processes of collisions with each other, sublimation and the photo-processing may lead to reducing of a diameter of the dust particles. For the dust particles with different chemical and mineralogical compositions, peculiarities of the evolutionary process and the time period from formation to destruction thereof, may be different, as well.

The dust particles of small sizes can be easily swept out of the central areas of the solar system under the solar radiation pressure. The light dust particles, when adsorbing and re-radiating the sunlight photons, will be slowed and moving towards the solar corona, while the small and light dust particles will be pushed out to the peripheral areas of the solar system. However, the aforementioned destructive processes will ensure a growth of new dust masses – different disperse dusts of various sizes and chemical-and-mineralogical compositions. Thus, the overall picture will be as follows: (1) the cloud loses the dust particle of small sizes; (2) the cloud obtains a new dust matter, which is still unprocessed by external factors.

In our view, during these two processes, their complementarities lead to a certain balance due to the presence of small dust particles. Such a balance can be determined as a permanent loss with a steady substitution.

More and more new small dust particles are swept out of the solar system. At the same time, more and more new dust particles obtain smaller sizes, as a result of the evolutionary process. At any selected moment of time t, a finite number n of the small dust particles will be present in the dust cloud, n_1 being the dust particles that will be ‘swept out’, and n_2 being the dust particles that are ‘formed’ (with reduction to a relevant size).

$$n = n_1 + n_2/t = \text{constant}. \tag{1}$$

The balance will be fair for the particles of $d < 400$ nm size. The given balance established by the above mentioned processes and expressed in coexistence of the old (swept out) and new (formed) dust particles, will determine the presence in the interplanetary dust cloud of a hardly detectable component in the form of a complex of fine disperse dust with $d > 10$ nm sizes of individual dust particles. This hardly detectable component may consist of different dispersed nano-dust particles in the $400 > d > 10$ nm size range. These nano-dusts and the cloud formations of the nano-dusts will be hardly detectable by means of the standard methods of observation.

Individual nano-dust particles will be characterized by a set of physical parameters including mass, size, shape, density, albedo, etc. Taking into account the external factors (collisions, absorption of radiation, etc.) a temperature of a substance of the dust particle shall be considered as one of the essential variable parameter.

Difference in mass, size and shape, relatively hot or cold nano-dusts create dust complex scattered in space, which, in its part, is a component of the interplanetary dust cloud. Taking into account a low spatial concentration of the interplanetary dust, it would be easy to assess a degree of complexity of detectability of the nano-dust. Physical parameters of the nano-dust particles will vary with time, including loss in mass, reduction in sizes and change in shape of the dust particles. The nano-dust particles may have various chemical and mineralogical compositions. Features of these compositions will be determined, first of all, by origin of the dust matter. The nano-dusts of the cometary and asteroid origin, apparently, will differ from each other by composition. We sub-divide the nano-dusts according to their chemical and mineralogical compositions, by the following types: (1) inorganic dust – silicates, etc.; (2) organic mineral dust – carbonaceous particles, nano-diamonds, etc.; (3) metallic dust – (Fe–Ni); (4) icy dust (ice H_2O etc.); (5) organic icy dust (frozen hydrocarbon particles FHP); (6) dust of a complex composition (silicate core – icy mantle, carbonaceous core – icy mantle, etc.). A spatial distribution of the above indicated types of nano-dusts will be mainly anisotropic, irregular or probably, time-variable.

Generally, the hardly detectable component of the interplanetary dust cloud in the form of a cloud formation of nano-dust, by its chemical and mineralogical qualities may be of a complex nature, if each cubic unit of the space contains simultaneously the silicate, organic, icy, and metallic nano-dusts.

This type of mineralogical composition may be determined as 'multi-mineral', that reflects both the physical and chemical peculiarities of the evolutionary process of small bodies of the solar system.

The nano-dust of different chemical and mineralogical composition will be characterized by a continuous scale of sizes, in the $\Delta d \approx 390$ nm interval. Each particular value of diameter d_1 of the nano-dust particle will be followed by a higher value of diameter d_2. In other words, the silicate, icy and other dust particles will be characterized by successively increasing(decreasing) diameters of individual dust particles. Minimal or maximal values of the diameters of the dust particles of a concrete chemical and mineralogical composition can be presented depending on the quantity (concentration) of the dust particles $n = f(d)$. For instance, the nano-diamond dust particles with $d = 50$ nm diameter (section) may prevail, or an absolute minimum of the icy particles with $d = 100$ nm diameter may be presented. Prevalence of sizes of the specific nano-dust particles, or a lack of others, will reflect a concrete state of a given dust segment, including stage of its evolution, and, can even indicate the level of contribution of the concrete parent bodies.

The nano-dust particles may fully or partly consist of the following minerals: quartz SiO_2, corundum Al_2O_3, forsterite Mg_2SiO_4, enstatite $Mg_2Si_2O_6$, periclase MgO, kamasite FeNi, diamond C, etc.

The nano-particles consisting of the ice H_2O may have different sizes in the 390 nm interval. The frozen hydrocarbon particles FHP of the nano-metric sizes (Simonia 2007, 2011) consisting of the frozen mixture of polycyclic aromatic hydrocarbons and n-alkanes, can also be included in the composition of a hardly detectable dust formation. All the above proposed chemical and mineralogical types of the nano-dust will form a multi-mineral complex of the hardly detectable dust matter of the interplanetary cloud. It should be noted here that the multi-mineral complex may also cover the nano-silicone dust particles. Besides, the metallic nano-dust of the nickelous-iron form may also be included in the composition of a hardly detectable dust cloud, by assuming a possibility of the formation of the nano-particles of the nickelous-iron in conditions of the rarefied interplanetary environment, as a result of the evolution of the parent bodies.

The nano-dust particles of the hardly detectable interplanetary cloud may have various geometrical shapes, including the spherical symmetric nano-dust particles, cylindrical nano-dust particles and the particles with irregular shape. It cannot be excluded that the shape of the nano-dust particles are in correlation with their chemical and mineralogical composition. For example, the spherical silicate nano-dust particles, the metallic nano-particles of a prolonged shape, the disc-shape icy nano-dust particles containing the frozen mixture of polycyclic aromatic hydrocarbons. All the above considered physical and chemical properties of the dust, including ranges of their sizes, are relevant for a hardly detectable component of the interplanetary dust cloud. A range of sizes of the nano-dust particles in the 390 nm interval, will be predetermined to a higher extent, a nature of such hardly detectable component.

3. External influence on the hardly detectable nano-dust

A hardly detectable component of the interplanetary dust cloud consisting of nano-dust, is subjected to various types of infuence of external factors and forces, including the gravitational and electromagnetic forces. At the same time, each individual nano- particle and the hardly detectable dust component, in general, will be the subject of different interactions, micro- and macro-phenomena. Every individual nano-particle and hardly detectable dust complex will participate in the following interactions: (1) dust–dust collisions; (2) dust–gas collisions; (3) dust sublimation; (4) absorption of electromagnetic and corpuscular radiations by the dust, with a possible re-radiation; (5) scattering of the passing electromagnetic radiation by the dust complex; (6) polarization of the passing radiation by asymmetric nano-particles; (7) enrichment of nano-dust with different ions making up the composition of the solar wind. It is necessary to add here that the metallic nano-particles, where chemical and mineralogical composition are analogical to one of the meteorite, will participate in one more interaction, namely, the interplanetary magnetic field lines. This will be expressed in movement or regulation of the electrically charged metallic nano-dust particles along the interplanetary magnetic field.

A hard ultraviolet solar radiation and the fluxes of the energetic electrons of the solar wind (in particular, after the proton flare) will have a noticeable influence on the surface of the nano-particles, that may cause formation of the superthin refractory mantles, which, by time, will cover the surface of the nano-particles and, turn it into a kind of nano-cores.

Absorption of ultraviolet solar radiation by nano-particles of the mineral and icy types may lead to photoluminescence or infrared fluorescence of the dust particles (Simonia 2013).

Local decrease of a medium temperature, as well as other processes, may stimulate the de-sublimation with the formation of new additional thin superficial layers – the icy mantles. The above described processes of interaction of the nano-dust of the hardly detectable cloud component determine a nature of evolution of such nano-dust. Moreover, these processes will determine destruction of the nano-particles, their deceleration, displacement from the central areas of the solar system, chemical transformation and other parameters of their evolution.

4. Possible paths of detection of the nano-dust of hardly detectable dust component

To detect the nano-dust clouds, i.e., the hardly detectable component of the interplanetary dust cloud, a high-sensitive ground-based or orbital instrument – the radiation receivers are required. It is necessary to take into consideration that just a specificity of interaction of the nano-particle with the external radiation predetermines a degree of complexity of detection of the dust and the specific methods of revealing thereof. It is necessary to single out the following processes: (1) absorption and re-emission of the solar electromagnetic radiation by the nano-dust; (2) absorption and re-emission of the electromagnetic radiation from external sources – planets and small bodies of the solar system, by the nano-dust; (3) polarization of the light passing from the planets, small bodies of the solar system and the stars of various spectral types by the asymmetric nano-particles; (4) scattering the light passing from the planets, small bodies of the solar system and the stars of various spectral types by the asymmetric nano-dust.

In fact, the nano-particles will interact directly with the solar radiation as well as with the sunlight reflected from the bodies of the solar system. The nano-dust can also interact with radiation from the stars. Results of the above indicated interactions – absorption, re-radiation, polarization and scattering, should be recorded and clearly identified. Absorption of the solar ultraviolet radiation by the complex of the nano-dust may lead to photoluminescence or infrared fluorescence of the dust.

A contribution of luminescence of the interplanetary nano-dust in the night sky glow with taking into account rarefaction of the dust matter and a relatively low quantum yield of luminescence of silicates, will be insignificant and hardly detectable. The reflected solar radiation, as well as the radiation of the stars, cannot cause an intensive photoluminescence of the nano-dust. Therefore, detection of the nano-dust due to its possible luminescence will be rather difficult.

The nano-dust component of the interplanetary dust cloud in conditions of a low-rate spatial concentration of nano-particles, will not cause a well-expressed polarization of the passing light. Besides, any unidentified absorption or emission in the spectra of external objects (planets and stars) must be an object of thorough studies for the purposes of their identification. Proceeding from the aforementioned, we may conclude that a process of scattering by the nano-dust of the passing light of the Sun, planets, small bodies and stars, can be considered as a main indicator confirming the existence of the interplanetary nano-dust.

5. Scattering the light by hardly detectable dust component

Bodies of the solar system: planets, asteroids and transneptunian objects, are surrounded by the dust matter, which forms the interplanetary dust cloud. This dust cloud formation interacts with an external radiation and absorbs and scatters it. We assume that the nano-dust forms a hardly detectable component of such a dust cloud, since in turn, it is the cloud of the nano-dust.

The Sun–Earth–TNO spatial system surrounded by the nano-dust, may be considered as a certain natural 'laboratory' for researching the physical macro-phenomena. The Rayleigh scattering of light by the complex of the nano-dust, can be one such macrophenomenon. We assume that the sunlight passing through the nano-dust complex is scattered. Thus, a conditional observer, if staying on the surface of one of the TNO, can see the Sun as a more red object. In other words, we think that the sunlight passing through the dust masses of the nano-dust is scattering in the shortwave range to the space, and reaches the TNO with its long-wave range only. Therefore, the transneptunian objects with comparably dense nano-dust complex, situated in the ecliptic plane far from the Sun, will be illuminated by more red sunlight. Naturally, in such a case, the diameters/sections of the nano-particles will be $d < 400$ nm. Only this kind of nano-dust will lead to a well-expressed reddening of the sunlight. As for the real observer on the Earth, being also in the ecliptic plane, the above described macro-phenomena will be complicated by additional scattering of reddish sunlight reflected from the TNO surfaces. Such additional reddening may be conditioned by bigger nano-particles – the elements comprising of nano-dust clouds. We assume, that for an observer from the Earth, the coefficient of absorption by the nano-dust of the passing light reflected from the TNO surfaces (by line-of-sight, observer – TNO) can be expressed as follows:

$$\alpha \sim 1/\lambda^2, \tag{2}$$

where λ is the wavelength of the radiation. Therefore, as a result of two-stage scattering the sunlight by nano-dust clouds, the transneptunian objects with a small orbital inclination, will be observed from the Earth as reddish, while in case of the transneptunian objects with a large orbital inclination, it will be bluish. In the first case given above, this will be conditioned by passing the sunlight through more extensive nano-dust complex, while in the second case – by passing the sunlight through the thinner part of nano-dust cloud. Variations of density of the nano-dust cloud, its spatial inhomogenity and any kind of irregular distribution will lead to variations of the TNO color, where the objects located at the same distances and having similar orbital inclinations, may somehow differ from each other by color.

Taking into consideration a high degree of spatial rarefaction of the interplanetary nano-dust, we may conclude that the above considered macro-phenomenon will only stipulate some color change of TNO towards reddish and bluish. The nano-particles of $400 > d > 10$ nm diameters will stipulate scattering the sunlight of a shortwavelength range into the surrounding space and thus, will precondition the reddening of the passing light on the radius-vectors of the Sun–TNO–observer. Such a possible macro-phenomenon may become a basic indicator of the presence of the nano-dust in the interplanetary dust cloud in the hardly detectable component thereof.

For confirming existence of the macro-phenomena proposed by us, the following can serve as arguments: (a) spectral features of the transneptunian objects; and (b) photometric features of the transneptunian objects.

It should be noted that both spectral and photometric features of these objects have been identified with the help of the empiric data obtained as a result of the regular observations of the TNOs (Barucci *et al.* 2008; Licandro *et al.* 2006; Rabinowitz *et al.* 2005). Point (b) deserves special attention with regard to an earlier established regularity of changing the TNO color indexes depending on their orbital inclinations. Namely, several authors have identified a common trend in the changes of B–R within the interval $25° > i > 0°$. They have demonstrated the so-called ‘cold’ TNOs with the orbital inclination $i \leq 5°$, which are reddish, while the so-called ‘hot’ TNOs with the orbital inclination $i > 5°$, are bluish. Some authors indicate the value of the orbital inclination $i = 12°$, as a conditional border between the ‘cold’ reddish ($i \leq 12°$) and ‘hot’ bluish ($i > 12°$) objects (Cruikshank *et al.* 2007; Doressoundiram 2003; Trujillo & Brown 2002; Peixinho *et al.* 2008). In any case, the empirical data unambiguously indicate the presence of two classes of TNOs: the reddish ones, which are located near the ecliptic plane, and the bluish ones, which are significantly inclined towards the orbital plane of the earth. Naturally, certain variations are observed in their specifications. We discuss here the statistical data rather than the

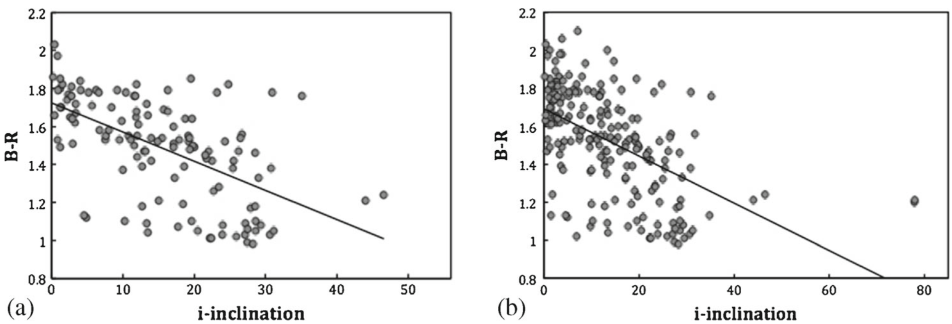

Figure 1. (**a**) B–R color vs. i-inclination for $D > 200$ km ($N = 127$) TNOs. There is very strong and significant Spearman's rank correlation ρ(B–R, i) $= -0.61 \pm 0.06$, SL $> 7.6\sigma$. (**b**) B–R color vs. i-inclination for $D > 300$ km ($N = 64$) TNOs. Spearman's rank correlation is ρ(B–R, i) =–0.64 $\pm$ 0.08, SL $>5.6\sigma$.

physical parameters. Nevertheless, the existence of the reddish and bluish TNOs is already a well-established fact.

In our view, such a duality of the color characteristics (color-indexes) of the TNOs can be explained well within the scope of the macro-phenomena proposed by us, where the solar radiation, when passing through the nano-dust complex, is scattered and reaches the surface of the TNO with its long-wavelength range, while thereafter, when becoming reddish and reflected from the TNO surfaces, is subjected to extra scattering and reddening while passing through the nano-dust complex back towards the terrestrial observer.

The above mentioned results of dependence on the changes of the color indexes on the orbital inclination of the TNOs may serve as a serious argument in favor of credibility of the macro-phenomenon proposed by us. We decided to conduct an additional analysis of the 'color index – TNO orbital inclination' dependence.

By using the data concerning TNO published by PDS (Planetary Data Center, University of Maryland) and applying the Spearman's (1904) rank-correlation ρ as an effective statistical method, we have established the value of correlation between color and TNO orbital parameters (including the orbital inclination) for the transneptunian objects of different classes selected by diameters $d < 80$ km, $d > 80$ km, $d > 100$ km. Our results are in good correlation with earlier published results.

We have built curves, which reflect changes of the value of the TNO color indexes from the orbital inclination B–R, i (Figure 1a, b).

A major result obtained by us, is obvious. By increasing the orbital inclination of TNOs of different diameters, they become more bluish. This outcome may be considered as an important argument in favor of the above described macro-phenomenon.

6. Discussion

The interplanetary dust cloud has been the object of many years of regular scientific researches. The lenticular dust formations are investigated by various methods of modern astronomy.

The dust and gas are the main components of the interplanetary matter, which is an object of ground-based and orbital observations.

Here we propose the model of interplanetary nano-dust complex – a component of the interplanetary dust cloud of the solar system. We propose to consider this complex of interplanetary nano-dust as hardly detectable and the most fine dispersed dust component of the interplanetary cloud. In the interplanetary space, the mineral and icy nano-dust paricles are subjected to various influences by external forces and factors, namely, when interacting with the gravitational and electromagnetic forces. A spatial component of the interplanetary dust matter in the form of nano-dust, is a natural evolutionary stage in the course of origin, development and disappearance of the dust matter of our planetary system. A hardly detectable character of the nano-dust component is conditioned by its nature, super-small sizes of the individual dust particles and very low spatial concentration of the nano-dust complex. Registration of photoluminescence or polarization of the nano-dust matter is quite a difficult instrumental task. Polarization of light by the interplanetary micro-dust was investigated by several authors (Vanysek 1970; Renard *et al.* 1995; Levasseur-Regourd *et al.* 2012; Zhelezov *et al.* 2014; Fornasier *et al.* 2015). Though the possible polarization of light by interplanetary nano-dust is not studied yet, we assume that one of the most important indicators of existence of the hardly detectable component of the interplanetary dust cloud is scattering the passing sunlight by the nano-dust. If the dimensions of nano-dust paricles of the hardly detectable component are $d < 400$ nm, then the solar electromagnetic radiation will be scattered by such nano-dust throughout the interplanetary space, and the passed and remaining radiation will be of a long-wavelength within the limits of Rayleigh mechanism.

Thus, the bodies situated far from the Sun, such as the transneptunian objects, will be illuminated by the reddish sunlight. Then, this light reflected from the surface of TNOs will be subjected to additional scattering (and reddening) by the nano-paricles of larger sizes, when passing through the nano-dust complex from the TNO to the terrestrial observer. For the given macro-phenomenon, we have proposed to consider the coefficient of absorption α with that inversely proportional to λ^2. The interstellar extinction of light depends on radiation wavelength as $1/\lambda$. The spatial density of the interplanetary nano-dust cloud is probably higher than the interstellar dust complexes. Therefore we suggest to consider absorption coefficient for the interplanetary nano-dust as $1/\lambda^2$.

We also demonstrated (examples of TNOs of different diameters) that dependence of change of the color-index on the orbital inclination of TNO has a specific character.

We confirmed the earlier established trend for TNO to become blue with an increase of the orbital inclination. Besides, a question arises regarding possibility of detection of the scattered light, as of a certain diffuse radiation.

An intensity of the sunlight scattered in the surrounding medium (scattered by the nano-dust) may not be of a high rate. This shortwavelength glow may be rather insignificant in terms of its contribution in the zodiacal light. There also exist some additional counter-arguments, which, taken together, provide the following: (1) dynamically cold and hot TNOs have different paths of evolution; (2) reddish color on surfaces of the TNOs is conditioned by continuous influence of electromagnetic and corpuscular radiations and peculiarities of the chemical composition of their surfaces. Surfaces of the dynamically different TNO, while being subjected to constant external influence are processed and they demonstrate specific spectral and photometric features. The above mentioned counter-arguments are important and, as of today, they are acknowledged as the advance view, as a minimum. However, how can we demonstrate the existence of a hardly detectable component of the nano-dust? In our view, it can be demonstrated (confirmed) just by Rayleigh scattering, where TNOs with a small orbital inclination are reddish, while TNOs with a bigger orbital inclination are bluish. The facts of dynamical differences and photo-processing the TNO surfaces are not disputable. We suppose that scattering the sunlight, probably by the existing nano-dust, may take place, which contributes to reddening of the cold TNOs.

In our view, further researches in this field may have good perspectives, namely, if take into account that some other planetary systems of stars of various spectral types, may also have the nano-particle clouds. In this regard, the unidentified absorption in the spectra of different stars may become an indicator of the presence of such nano-dust clouds.

We assume that the space experiments may be promising, namely, the current space missions may be considered as a source of obtaining valuable data concerning the interplanetary nano-dust. The spacecrafts being sent out of the Uranus and Neptune orbits can provide us with new spectral and photometric data, which would be useful for conducting further analyses within the scope of this problem, namely, obtaining values of the magnitudes (brightness) of the Sun and the Moon in different spectral ranges by means of the instruments being at the transneptunian distances that would open new opportunities for identifying possible reddening of the radiation of the Sun and of the light reflected from the Moon.

7. Conclusion

Interplanetary dust is a carrier of important information concerning origin and evolution of the solar system. The dust cloud matter is studied by various methods of celestial mechanics, astrophysics and cosmochemistry.

We suppose the existence of the hardly detectable component of the interplanetary dust in a form of the nano-dust cloud. This hardly detectable nano-dust formation may scatter the sunlight and cause reddening of the far objects, the TNOs. Various discussions on possible existence of a hardly detectable component of the dust matter of the solar system, seem to be necessary, in our opinion. Both experimental and theoretical analyses of this hypothesis could play an important role in confirming, rejecting or modernizing the view introduced by us.

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