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Dust in Central Regions of Five Seyfert Galaxies

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On the basis of multicolour *UBVRIJHKL* photometry done by Lebofsky and Rieke (1980) for five Seyfert galaxies III Zw2, 3C 120, NGC 1275, 4151 and 5548, the temperature and total mass of the interstellar dust, surrounding in a shell the galaxy nucleus, is studied. The radius of the shell is estimated by three independent ways, applying either the time delay between a change of luminosity of the central nonthermal source and the corresponding change in thermal IR emission of the dust; or the temperature estimation from the spectral index of the thermal emission; or from the thermal balance of dust particles in the shell. The estimated masses of the dust in the shell range at maximum to 10^3 $M_\odot$, the shell radii range at most some tens of parsec and dust temperatures are spread from 400 K to 800 K.

Na základě mnohobarevné fotometrie *UBVRIJHKL*, kterou provedli Lebofsky a Rieke (1980) pro pět Seyfertových galaxií III Zw2, 3C 120, NGC 1275, 4151 a 5548, je studována teplota a hmotnost mezihvězdného prachu ve slupce obklopující jádro galaxie. Poloměr slupky je odhadován třemi nezávislými způsoby, podle časového zpoždění mezi změnou luminosity centrálního netermálního zdroje a odezvou termálního IR záření prachu, a podle teploty prachu určené buď ze spektrálního indexu termální emise nebo z tepelné rovnováhy prachových zrn ve slupce. Odhadnuté hmotnosti prachu ve slupce dosahují maximálně 10^3 $M_\odot$, poloměry slupek nejvýše několik desetin parseku a teploty prachu leží mezi 400 K a 800 K.

На основе наблюдательных данных полученных в многоцветной системе *UBVRIJHKL* Лебофским и Риекем (1980) для пяти Сейфертовых галактик III Zw2, 3C 120, NGC 1275, NGC 4151 и NGC 5548 изучается температура и масса межзвездной пыли в оболочке окружающей ядро галактики. Радиус оболочки подвергается трем независимым оценькам, на основании временного опоздания реакции инфракрасного излучения пыли на переменную яркость центрального нетермального источника, и на основе определения температуры пыли посредством спектрального показателя или основаясь на термальном равновесии отдельных пылинок в оболочке. Приближенно определенные массы пыли в оболочке достигают по крайней мере максимум 10^3 $M_\odot$, радиусы оболочек протягиваются максимально до нескольких десятых парсека и температуры пыли движутся в интервалу с 400 K до 800 K.

1. Introduction

Seyfert galaxies are known to have massive, compact and strongly active nuclei. The activity, i.e. the variability, the presence of emission lines in their spectra and

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high Doppler shifts have probably common origin in wide class of objects ranging from Seyfert galaxies to quasars, where the level of activity is variable from one kind of object to another. It is convenient and physically meaningful to divide these objects into three categories:

Sy2 Seyfert galaxies of type 2, characterized by having both permitted and forbidden lines of the same width, equivalent to velocities typically 600–2000 km s^{-1};

Sy1 Seyfert galaxies of type 1, characterized by very broad permitted lines and much narrower forbidden lines; the total halfwidth of the forbidden lines being approximately of the same order as in the type 2 Seyferts, while broad permitted lines indicate velocities up to 10 000 km s^{-1};

QSO quasars, which appear spectroscopically to be similar to type 1 Seyferts.

Assuming the cosmological interpretation of the redshifts and Hubble constant H_0 = 100 km s^{-1} Mpc^{-1} (unless stated otherwise), the objects listed above differ significantly in their luminosities. At a rest wavelength of 300 nm, the brightest ordinary galaxies in clusters have monochromatic luminosity of order 10^{20} W Hz^{-1}, type 2 Seyferts range from 10^{20} to 10^{21} W Hz^{-1}, type 1 Seyferts go from 10^{21} to 10^{22} W Hz^{-1} and quasars have a spread from 10^{22} to 10^{25} W Hz^{-1}.

Lebofsky and Rieke (1980) recently made a visual and near infrared photometry of five active galaxies III Zw2, 3C 120, NGC 4151, NGC 1275 and NGC 5548, classified commonly as type 1 Seyferts, e.g. by Minkowski (1968) and Yee (1980). Considering Seyferts and quasars together, there appear to be four distinct possible sources of continuous spectra, covered by the multicolour *UBVRIJHKL* broadband photometry. They are:

A – a nonthermal source with moderately flat spectrum in the violet and ultraviolet spectral region, characterized by quickly fluctuating luminosity;

B – a source giving nonthermal power-law spectrum in the visual and near infrared spectral region;

C – a thermal infrared source, probably interstellar dust heated by the sources A, B; and

D – ordinary stellar radiation as in normal galaxies.

Type 2 Seyfert spectra are dominated by sources D and C, source A probably exists here too, heating the dust and providing ionizing radiation. Type 1 Seyfert spectra are dominated by sources A and B. If relative fluxes from the sources A and B are the same for both types of Seyferts, then in type 2 galaxies, the implied intensity of source A would leave source B practically undetectable if compared with the background stellar radiation of galaxy surrounding the nucleus.

Analogically, if the luminosity of type 1 is considered, one would not expect source D to be a significant part of the radiation in such objects. The difficulties in recognizing source C with respect to the strong source B and A presumably implies a quite limited amount of dust, since there is adequate UV radiation from A available to heat it, if present, of course.

Quasars are dominated by sources A and B and the same comments about sources C and D in type 1 Seyferts apply even more strongly. Type 1 Seyferts and quasars appear to be very similar objects, with quasars simply being the most luminous of them. On the other side, type 2 Seyferts probably represent the opposite low luminosity end of the general class including all three types of objects. Thus, it seems indeed probable that all three types have sources A, B and D, and perhaps even C.

As far as continuum is concerned, the luminosity of sources A and B is sufficient to determine the classification. It should be noted that part of the distinction between Seyferts of type 1 and 2 is a consequence of obeserving conditions and the distance. Thus a type 1 Seyfert, if observed with a large aperture, might show sources D and perhaps C. Apertures applied by Lebofsky and Rieke (1980) were 23″ for *UBVRI* and 8.5″ for *JHKL*. Therefore, the question concerning the actual distance of dust from the central sources A and B appears to be the substantial one.

2. Variations in the thermal, visible and ultraviolet radiation of Seyfert galaxies

Photometric data obtained by Lebofsky and Rieke for the galaxies listed above are summarized in Fig. 1. Normalized infrared light curves of these galaxies are

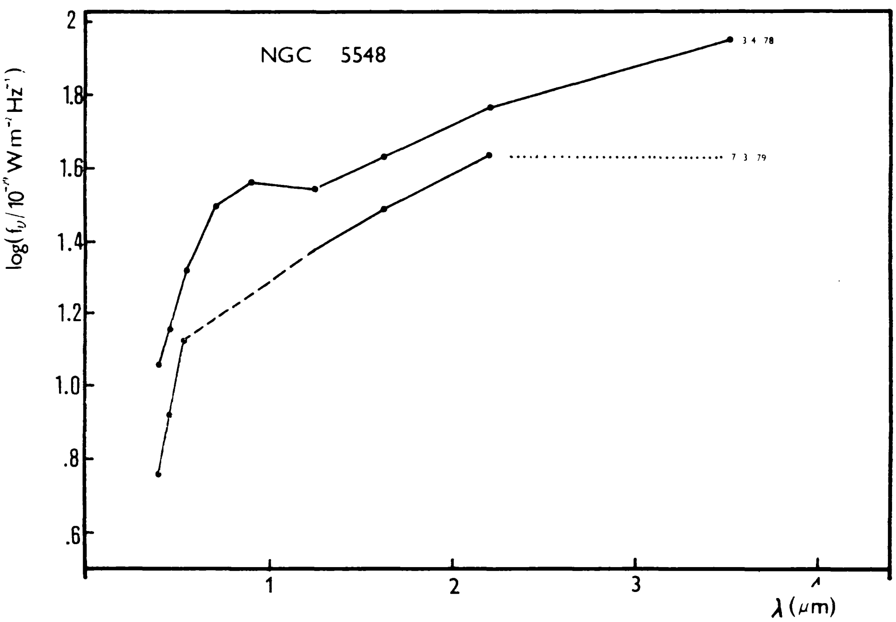


Fig. 1. Infrared spectra of five Seyferts measured by broad-band photometry (according to Table 1).

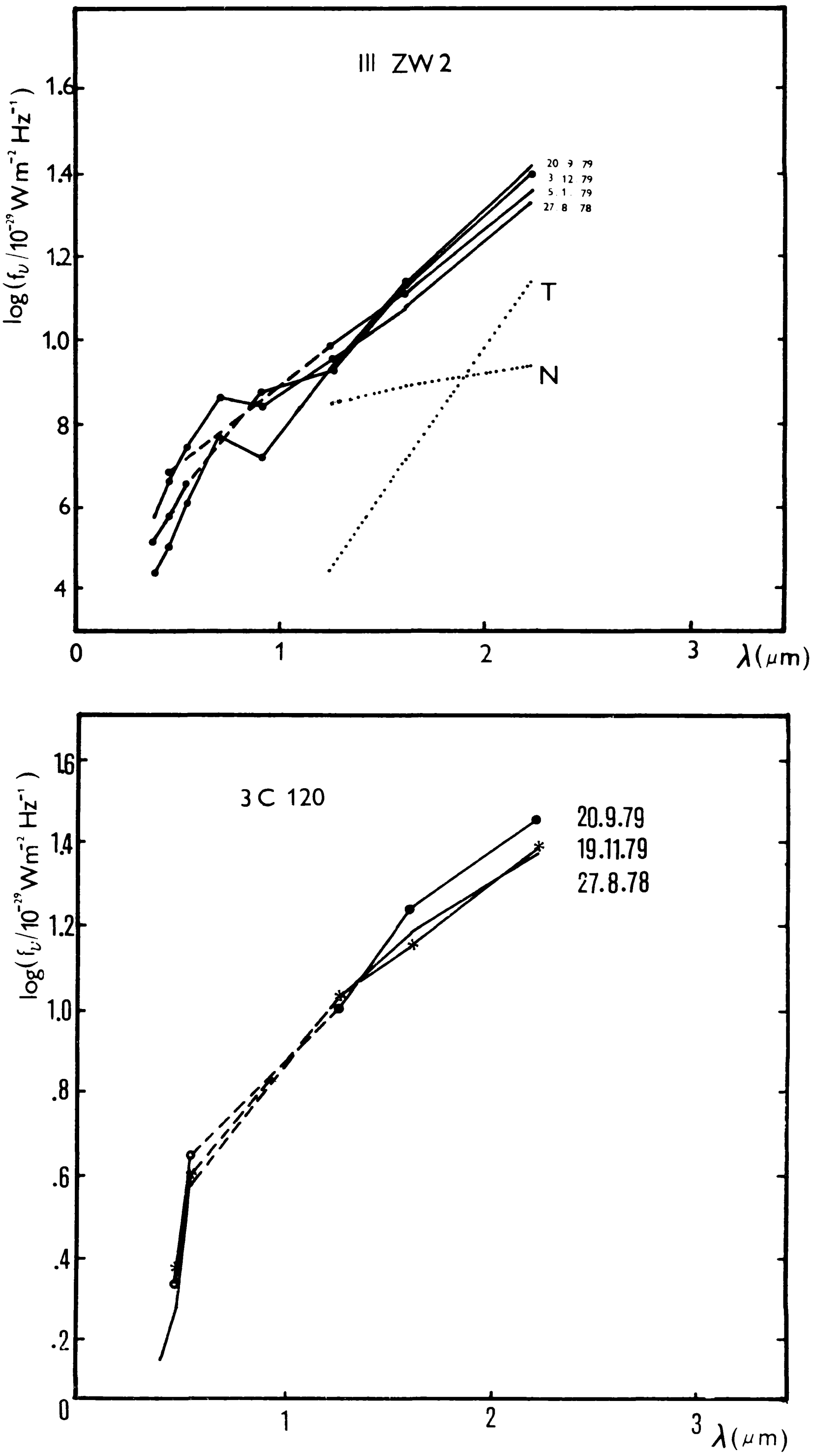
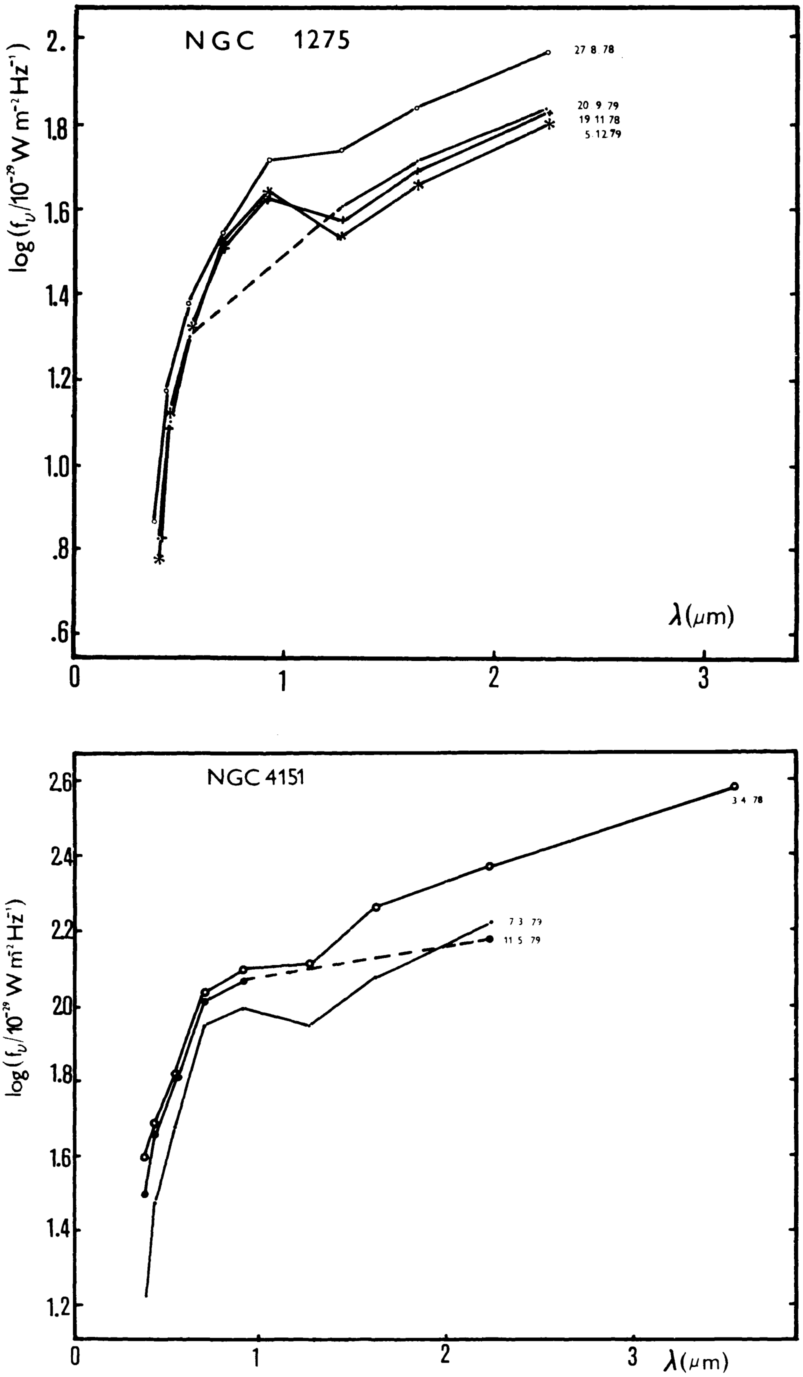

III ZW 2
log(f_ν/10^-29 W m^-2 Hz^-1)
1.6
1.4
1.2
1.0
8
6
4
20 9 79
3 12 79
5 1 79
27 8 78
T
N
0
1
2
3
λ(μm)
3 C 120
log(f_ν/10^-29 W m^-2 Hz^-1)
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
20.9.79
19.11.79
27.8.78
1
2
3
λ(μm)

Fig. 1 cont.



NGC 1275
27 8 78
20 9 79
19 11 78
5 12 79
log(f_ν/10^-29 W m^-2 Hz^-1)
λ(μm)
NGC 4151
3 4 78
7 3 79
11 5 79
log(f_ν/10^-29 W m^-2 Hz^-1)
λ(μm)

Fig, 1 cont.

plotted in Fig. 2 (by Lebofsky and Rieke (1979), (1980)) for a period over 12 years, putting the brightness in 1978 to be 1. The variability of IR excess is clearly shown for all of the galaxies.

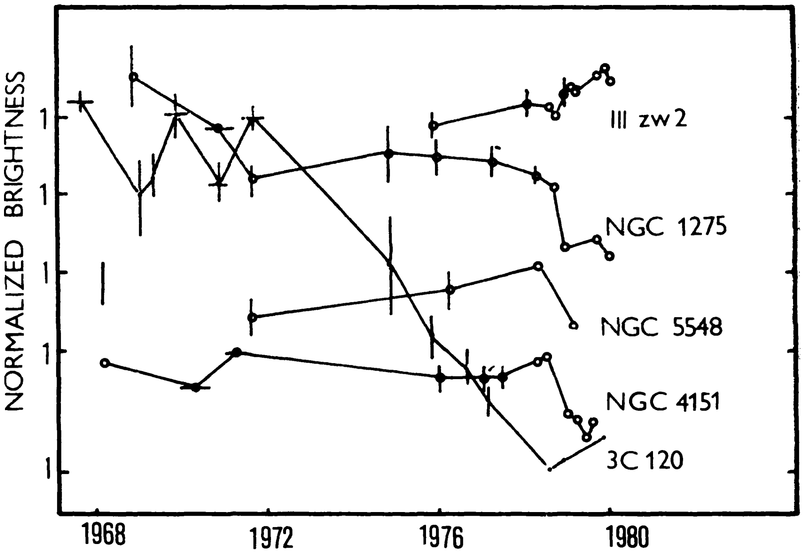


Fig. 2. Variability of infrared flux from five Seyferts (by Lebofsky and Rieke 1980). The spectrally averaged IR brightness for each galaxy has been normalized to 1.0 near the middle to 1978. The bar above 1968 shows the amplitude of variation of 20% of the normalisation value. When measurement errors exceed the sizes of the symbols, they are indicated with vertical bars. When measurements over an extended period have been combined into a single point, the total period of measurement is shown with a horizontal bar.

The simplest explanation for variations in infrared would be that a single, compact nonthermal central source affects by its own variations the whole energy output of the galaxy, neglecting the stellar source D, of course.

To put an upper limit on the dust amount in Seyfert nucleus, the correlation between light curves of sources A and C is to be discussed. Separation of the IR thermal emission from the nonthermal components was possible only in III Zw2 thanks to the sufficient set of data. Assuming that the observed continuum flux at band B goes entirely from the central nonthermal source and that its variations does not affect instantaneously the continuum at band K, then the nonthermal power-law continuum can be extrapolated from B and J to K by an iterative way, supposing the half amplitude of nonthermal variations at band J. The power-law spectrum from B to J has a spectral index -0.4 and produces nonthermal fluxes at J, H, K respectively 7.3, 8.0 and 9.0 mJy, while the thermal spectrum has spectral index -3 and contributes to fluxes J, H, K by 2.8, 5.3 and 14.2 mJy respectively, as measured on May 1, 1979 by Lebofsky and Rieke (1980).

Generally, if one can distinct between the thermal and nonthermal component of the infrared emission, one can find that the variations of nonthermal IR flux, visible and UV radiation are simultaneous, while changes of the thermal source C are delayed by time interval τ. Denoting $L_{NT}(t)$ and $L_{TIR}(t)$ the time dependence of the nonthermal and thermal IR luminosity respectively, the time delay τ can be found by minimizing

$$(1) \qquad S = \int_{t_0}^{t1} (L_{NT}(t - \tau) - L_{TIR}(t))^2 \, dt \,, \quad \text{i.e.} \quad \delta\, S(\tau) = 0 \,,$$

where time interval (t_0, t_1) must cover the substantial part of changes in both spectral regions. As shown in Fig. 1, the fotometric data cannot provide a reliable basis for the estimation of the time delay τ, because the minimum of $S(\tau)$ appear to be very flat and uncertain in most cases. Summarizing the time scales of variability of the galaxies, the characteristic time for rapid fluctuation of the nonthermal UV source is about some days, while the IR thermal respons is delayed by hundreds of days. For instance, the brightening of III Zw2 occured in infrared in September 1979, more than one year after the rise in its ultraviolet, optical and radio brightness.

The slope of the thermal spectrum of the infrared component in III Zw2 corresponds to a colour temperature about 1500 K (between 1.25 and 2.2 μm), approaching the temperature maximum below which interstellar dust grains can survive. On the other hand, nearly all Seyfert galaxies are strong emitters of far-infrared radiation, $\lambda > 30$ μm. The general shape of the spectrum of FIR excess resembles black body spectrum of low and moderate temperature, commonly higher than 20 K but rising up to few hundreds of kelvins in some places, especially in type 2 Seyferts. The IR excess can be easily explained as the thermal emission of the more distant dust from the central source. Some implications of this hypothesis will be discussed later. There is already evidence, that the longer the wavelength is, the longer is the time delay of change at this wavelength.

Additional arguments for the presence of the heated dust around nuclei of Seyfert galaxies presumably of type 2 can be derived from the 10 μm silicate absorption feature observed in spectra of most type 2 and type 1 Seyferts (Lebofsky and Rieke, 1979).

3. Model of a dust envelope around the galaxy nucleus

The actually observed rise of thermal emission delayed by τ after a nonthermal brightness increase places certain limitations on the size of the emitting dusty region. The most simple model explaining it consists from a pointlike source A and from a thin spherical shell filled by isothermal dust, surrounding the central source. The radius R of the shell is determined by τ and can be therefore expressed in light years (or light days etc.) by applying

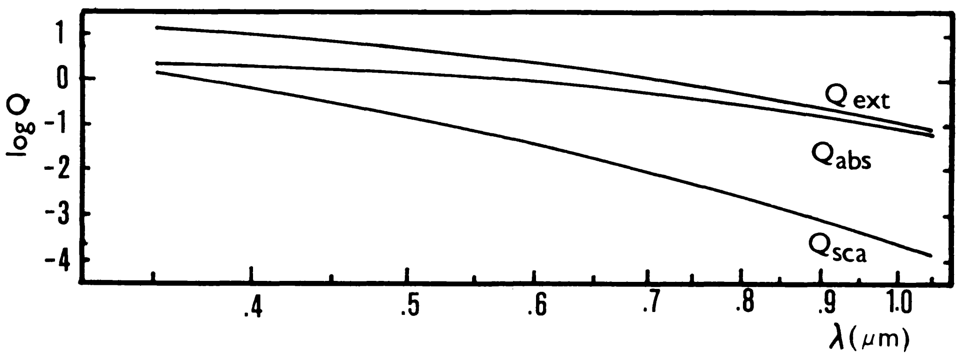
$$(2) \qquad R = c\,.\,\tau \quad (c = 3\,.\,10^8 \text{ m s}^{-1})\,,$$

or in parsecs, meters etc. Typically, the radius is expressed in some hundreds of light days, as can be seen in Fig. 1. Unfortunately, one cannot derive the better value of τ than previously, by means of Eq. 1.

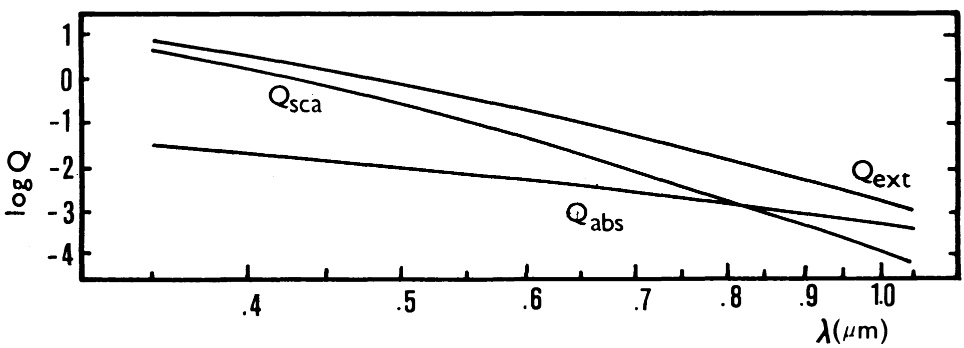
Independently, the size of the IR emitting region must satisfy the energy conservation law, balancing the incoming UV energy absorbed by the dust on the one side and the thermally re-radiated IR energy by the dust particles on the other side. Under conventional crude approximation that

- the grains are silicate with a higher albedo, characterized by the refractive index going from $m = 1.55-0.05i$ (nearly dielectric particles) to $m = 1.55-0.3i$ ("dirty silicates"); and that
- the representative shape of the grains are spheres with a mean radius $a = 1$ µm, so that Mie's theory or another equivalent procedure can be applied to determine the UV absorptivity and the IR emissivity, both given by the efficiency factor $Q_{abs}(\lambda, a)$ – Fig. 3.

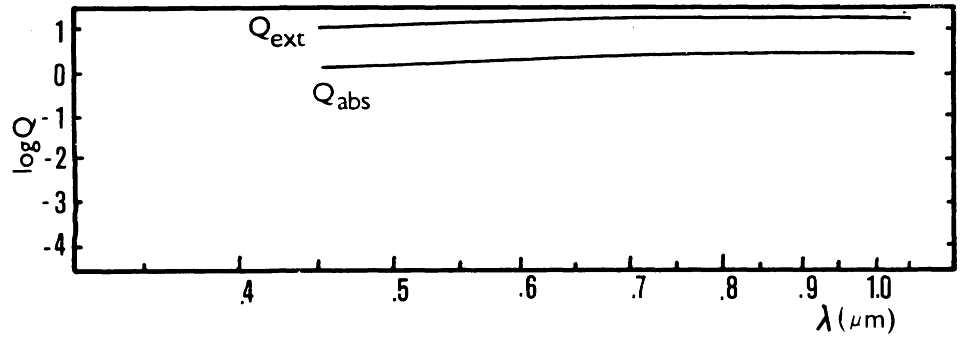
Fig. 3. Infrared efficiency factors Q_{ext}, Q_{abs}, Q_{sca} for polydisperse dust spheres characterized by mean radius a and complex refractive index m:



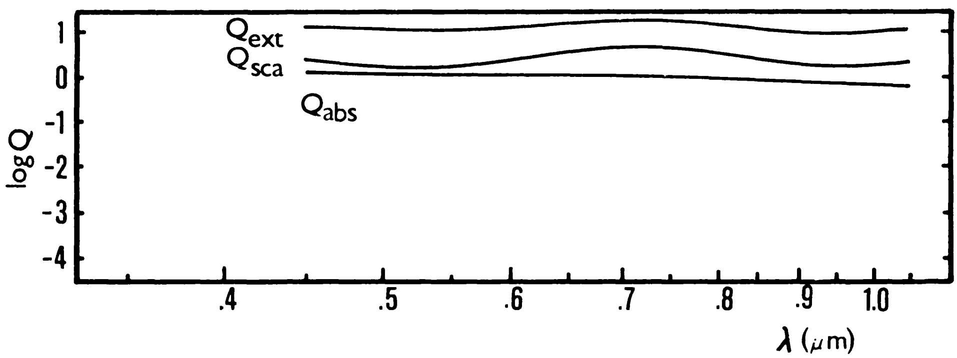
a) $a = 0.1$ µm $m = 1.6-0.3i$



b) $a = 0.1$ µm $m = 1.6-0.05i$



c) $a = 1\ \mu m$ $m = 1.6 - 0.3i$



d) $a = 1\ \mu m$ $m = 1.6 - 0.05i$

Hence, the energy conservation law written for one particle takes the form

$$(3) \qquad \int_0^\infty \pi a^2\, Q_{abs}(\lambda, a)\, \frac{L_{AB}(\lambda)}{4\pi R^2}\, d\lambda = \int_0^\infty B_\lambda(T_g)\, Q_{abs}(\lambda, a)\, 4\pi a^2\, d\lambda\,,$$

if the influence of collisions of hot plasma particles with the dust grains is neglected. In the equation above the luminosity L_{AB} of the sources A and B can be drawn from the photometric data. The temperature T_g of dust grains is to be estimated either from the slope of the thermal IR spectrum of from Eq. 3 by iterations improoving the values both T_g and R step by step until satisfactorily agreement with observational data at other wavelength is reached.

Since the iterative procedure cannot give a reliable picture about temperature in this simple isothermal model without additional information concerning the shape of the thermal spectrum, one free parameter — namely the distance R of dust from the center — is kept in the following calculations. Three possible values 0.2 pc, 0.4 pc and 0.8 pc are taken into account for the radius R. Thus, the most promissing value of R, and the other values bound to it, for instance the dust temperature T_g, can be obtained by comparing R with the time delay τ and with the shape of the thermal spectrum, if succesfully obtained from the photometry.

The first rough estimate of the equilibrium temperature of the grains at a distance R can be found by the following way. The integrand in the lefthand side of Eq. 3 is dominated by the shape of $L_{AB}(\lambda)$ reaching maximum in the UV spectral region. The absorptivity of dust is maximal for the UV radiation so that $Q_{abs} = 1$ without respect to the particle size a. Then $L = \int_0^\infty L_{AB}(\lambda)\,d\lambda$ is the total energy radiated by the Seyfert nucleus. The total brightness of the five Seyferts may be derived from Table 1, where either absolute visual magnitudes of the nucleus or nonthermal luminosities L_{NT} and $J_{H\beta}$, $J_{[OIII]}$ are given.

Table 1
(Minkowski 1968, Yee 1980)

Source	Class	z	m_V	M_{Vg}	M_{Vn}	L_n/L_g	$\log L_{NT}$	$\log J_{H\beta}$	$\log J_{[OIII]}$
III Zw2	transient QSO - Sy1	0.0890	—	—	—	—	37.30	35.52	35.12
3C 120	transient QSO - Sy1	0.0334	13.78	−21.2	−20.8	0.68	—	—	—
NGC 1275	Sy1	0.0177	12.3	−21.4	−19.7	0.08	—	—	—
NGC 4151	Sy1	0.0033	10.5	−19.5	−18.5	0.40	35.14	33.61	34.18
NGC 5548	Sy1	0.0166	12.9	−20.6	—	—	35.62	34.29	33.26

On the right-hand side of Eq. 3 dominates the integration over the infrared spectral region, where $Q_{abs}(\lambda, a) = Q_{abs}(a) =$ constant independent on the wavelength λ. The right-hand side thus transforms into the simple Stefan-Boltzmann law and temperature T_g follows as

(4) $$T_g = \left(\frac{L}{16\pi R^2 \sigma Q_{abs}}\right)^{0.25}$$

It should be pointed out that T_g is only slightly dependent on the size of dust grains (through the dependence of Q_{abs} on a), ranging from $Q_{abs} \ll 1$ for $a \ll 1\ \mu m$ to $Q_{abs} \simeq 1$ for $a \gg 1\ \mu m$.

With respect to the observational errors, the first starting approximation of T_g from Eq. 4 may appear as sufficient without any iteration described above.

Denoting N the total number of dust particles in the shell, the observed IR thermal flux F_λ can be written as

(5) $$F_\lambda = \frac{4\pi a^2 . N}{4\pi D^2} Q_{abs}(\lambda)\, B_\lambda(T_g)$$

where

(6) $$D = \frac{cz}{H_0} \quad (c = 3 . 10^8\ \mathrm{m\,s^{-1}},\ H_0 = 100\ \mathrm{kms^{-1}\,Mpc^{-1}})$$

is the distance to the galaxy if the redshift z is admitted as an indicator of the cosmic distances, and $B_\lambda(T_g)$ is the Planck function for the dust temperature T_g.

The most complete photometric data set given in Fig. 1 is obtained in band K (λ = 2.2 μm). Efficiency factor $Q_{abs}(\lambda)$ is nearly constant at this wavelength and equals to 0.04 for silicates with refractive index $m = 1.55 - 0.05i$. By means of Eq. 5 the total number N of particles in the model shell follows from these K-fluxes. The actual number N can substantialy differ from the computed one because of uncertain contribution of nonthermal radiation to the K-fluxes in some Seyferts.

Evaluating the total mass M of the dust in the model, it seems reasonable to suppose the bulk density of the dust material approximately the same as with the silicates, i.e. ϱ = 3000 kg m^{-3}. Hence the total mass M is

(7) $$M = N \cdot \tfrac{4}{3}\pi a^3 \varrho \,.$$

However, the total mass of the dust in the nuclear region of a galaxy obtained in such a way is sensitive on the particle size assumed,

(8) $$M \propto a \,.$$

Since there is at present no other way to confirm our reigning opinion about the particle sizes and size distribution in Seyfert and other galaxies as well, nothing other remains than see the value in Table 2 as highly tentative one. The same mentioned

Table 2

Source		Radius of the dust shell		
		0.2 pc	0.4 pc	0.8 pc
III Zw2				
D = 1.7 × 10^{25} m	T_g(K)	920	650	460
L_{NT} = 8 × 10^{37} W	N	1.8 × 10^{48}	3.2 × 10^{49}	2.0 × 10^{51}
	$M(M_\odot)$	1.0 × 10^{1}	2.0 × 10^{2}	1.3 × 10^{4}
3C 120				
D = 0.61 × 10^{25} m	T_g(K)	650	460	330
L_{MVn} = 2 × 10^{37} W	N	4.3 × 10^{48}	2.6 × 10^{50}	6.1 × 10^{62}
	$M(M_\odot)$	3.0 × 10^{1}	1.4 × 10^{3}	3.8 × 10^{5}
NGC 1275				
D = 0.34 × 10^{25} m	T_g(K)	430	310	220
L_{MVn} = 4 × 10^{36} W	N	5.2 × 10^{50}	1.7 × 10^{53}	6.9 × 10^{56}
	$M(M_\odot)$	3.3 × 10^{3}	1.1 × 10^{6}	4.4 × 10^{9}
NGC 4151				
D = 0.06 × 10^{25} m	T_g(K)	400	280	200
L_{MVn} = 3 × 10^{36} W	N	1.1 × 10^{50}	1.0 × 10^{53}	1.0 × 10^{57}
	$M(M_\odot)$	7.0 × 10^{2}	5.0 × 10^{4}	0.5 × 10^{9}
NGC 5548				
D = 0.32 × 10^{25} m	T_g(K)	360	260	180
L_{NT} = 2 × 10^{36} W	N	4.4 × 10^{51}	4.4 × 10^{54}	4.4 × 10^{59}
	$M(M_\odot)$	2.7 × 10^{4}	2.7 × 10^{7}	2.7 × 10^{12}

above about M apply even more strongly for the number N, since $N \propto a^3$. Hence, the value of N as an entry in Table 2 has an illustrative role only.

4. Basic data about five Seyfert galaxies

Following the previous classification, all the five galaxies belong to type 1 Seyferts, 3C 120 and III Zw2 being transient types between Sy1 and quasars. Fundamental physical data of all these galaxies are summarized in Table 1, taken by Minkowski (1968) and Yee (1980).

In the first four columns are names of the objects, types, redshifts z and apparent visual magnitudes m_V. M_{Vg} and M_{Vn} are absolute visual magnitudes of the galaxy as a whole and of its nucleus respectively, L_n/L_g is the ratio of the total energy output of the nucleus and of the whole galaxy. L_{NT}, $J_{H\beta}$ and $J_{[OIII]}$ are total luminosities of the nonthermal spectral component, of the permitted emission line Hβ and of the forbidden emission lines [OIII] respectively, all in watts. Hubble constant is assumed $H_0 = 100\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$.

5. Discussion

The luminosity of the IR source in II Zw2 is $\simeq 10^{11}\,L_\odot$ (Rieke, 1978) and the luminosity in the Lyman continuum must be at least $5 \,.\, 10^{10}\,L_\odot$. If the spectral index of the nonthermal continuum from the Lyman edge to 1 μm is -0.4, the luminosity over this spectral portion is $1.5 \times 10^{11}\,L_\odot$. Therefore, a significant part of the nonthermal UV and visible continuum is absorbed by dust and re-radiated in the infrared.

Spectral index -3 of the IR thermal continuum indicates the temperature of the dust about 1500 K, still below the limit temperature $\simeq$2000 K at which the grains evaporate. Lebofsky and Rieke (1980) suggest under assumption $H_0 = 55\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ that the 1500 blackbody shell can generate the observed IR flux has radius about 0.2 pc. However, the infrared source must be more extended and hence not so warm, since the column density of the grains toward the central source indicates a low optical thickness. They argue that the more distant dust (for instance at 0.6 pc) would require an optical depth only 10% of that estimated above, and that the UV absorptivity of the dust necessary for balancing the input/output radiation would be 16 times greater than in IR. Finaly, the more extended dust shell would smooth out every IR reaction on the rapid UV changes. Therefore, they concluded from the previous considerations and according to the time scale of the IR variability that the dust shell is thin and closely attached to, if not partially embedded in the ionized gas region producing the broad emission lines in type 1 Seyferts. Moreover, the colour temperature of dust may suffer from various distorsions of the spectrum, and cannot provide reliable values especially when derived from a narrow spectral region.

The conclusions mentioned above agrees in principle with the results given in Table 2. All values of L, N and M are computed with $H_0 = 50 \text{ km s}^{-1} \text{ Mpc}^{-1}$ to point out the correspondence and/or disagreement with the results by Lebofsky and Rieke (1980). Whenever replacing $H_0 = 50$ by $H_0 = 100 \text{ km s}^{-1} \text{ Mpc}^{-1}$ the values L, N, M are to be divided by 4, and the temperature approximately by 1.4. In case of III Zw2, the high temperature 1500 K would require an about 20 times more powerful central source (or even more) if $H_0 = 100$. The low mass of the 0.2 pc shell seems to be underestimated, and moreover, the radius 0.2 pc is less if compared with the time delay from 1 to 2 years as follows from Fig. 1. Therefore, either much lower dust temperature must be admitted, or the mean grain diameter is to be at least 10 times reduced, to $\simeq 100$ nm. Finaly, in the Seyfert galaxies seems the most probable that shell radius, for which M ranges from 10^2 to $10^4 \text{ M}_\odot$.

There are further arguments limiting the dust mass to lower values. Recent far infrared photometry by Smith et al. (1983) of some type 2 Seyfert galaxies, characterized by enhanced dust content if compared with type 1 Seyferts, reveal extended FIR source reaching in some directions up to few kiloparsecs. The observations in the spectral region from 30 to 170 μm indicate the dust temperature about 28 K and the far infrared emissivity $\simeq 10^9 \text{ L}_\odot$. Probably, for the majority of this emission is responsible the thermal radiation of the dust. Even if the detailed mechanism of the dust heating is still poorly understood, the role of star forming regions is probably more essential than the heating by the central nonthermal source. Star formation is more efficient in type 2 Seyferts (e.g. in NGC 1068 and NGC 4051, Smith et al. (1983)) since the FIR emission extends outside the nucleus and since the spectral character and molecular gas to dust ratio resemble that observed in galactic star formation regions and in other type 2 Seyferts.

Since type 1 Seyferts are less dusty than type 2, there is likely less material available to fill the central parsec. Part of that material lies in close contact with the hot gas in the nucleus, but the farther environment seems to be less populated, if not nearly empty. Supposing that this material is of the same nature as that in the star forming regions and in the galactic giant molecular clouds, its mass cannot exceed far the mass of the analogical objects studied in type 2 Seyferts and in our Galaxy. Therefore, the dust shell with radius about 0.5 pc appears the most convenient in III Zw2 and in 3C 120, while in the less luminous NGC 1275, NGC 4151 the dust can form a shell of radius about 0.2 pc and in the NGC 5548 even less radius is likely.

With improved angular resolution and with more extended series of photometric observations, the considerations given above could be refined to the extent enabling to analyze the temperature and other physical characteristics of the dust in Seyfert galaxies with more detail.

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