Astrophys Space Sci (2011) 332: 91–98
DOI 10.1007/s10509-010-0486-8

ORIGINAL ARTICLE

Organic component of cometary ice

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Received: 29 April 2010 / Accepted: 11 September 2010 / Published online: 28 September 2010

Abstract Investigations of the luminescence of frozen hydrocarbon particles of icy cometary halo have been made. The process of luminescence of icy particles in shortwavelength solar radiation field is considered. The comparative analysis of observed and laboratory data leads of 72 luminescent emission lines in the spectrum of 153P/Ikeya-Zhang comet. Several aspects of the problem are discussed.

Keywords Astrochemistry · Comets: individual (153P/Ikeya-Zhang) · Radiation mechanisms: non-thermal

1 Introduction

Resonance-fluorescent emissions of cold rarified comet atmospheres mark basic gas components forming these atmospheres. Emission lines of molecules and ions, such as C_2, C_3, CH, CN, CO_2, NH, OH, CH_{II}, CO_{II}, OH_{II}, and others are basic components of cometary spectra. Basing the contemporary views on chemical composition of cometary atmospheres on identification of molecular emissions of resonance-fluorescence nature, it is concluded that the molecules of comas represent daughter formations. Solar shortwavelength electromagnetic radiation and fluxes of charged particles of the solar wind prevent hit of parent molecules into comas and comet tails, providing photodissociation and photoionization of molecules. The process of the molecules photodissociation and photoionization are ongoing in the near-nucleus space. Thus, the spectrum of any comet rich in emission lines witnesses only daughter molecules and cometary atmosphere ions. This fact is well-known. However, there exists different component of cometary spectra, representing series of narrow emission lines not subject to standard methods of identification, including the method of comparison with the laboratory sources of radiation. Multiple narrow lines of unidentified nature are found in the spectra of majority of comets. Along with narrow lines we come across some relatively wide bands not subject to standard identification as well. Such lines, on common agreement, are named unidentified lines. Many authors present the data on such emission lines in the tables and catalogues, publishing them along with the tables of identified emissions. Interest in unidentified cometary emission lines is caused, firstly, by unknown nature of these lines and, secondly, by impossibility (difficulty) of applying standard methods of identification to them. Origin of these lines has more than once become the object of researches. Main conclusions of these researches came to supposition on ionic nature of some emission lines of such type (Wyckoff et al. 1999; Kawakita and Watanabe 2002). However, majority of unidentified emission lines remained in the status of emissions of unknown nature. If relatively wide bands of unidentified nature observed in the spectra of ionic tails of comets can be linked with the corresponding ion, then multiple quite narrow unidentified lines observed in the spectra of comas demand thorough identification and discussion of other mechanisms of their excitation.

In the works by Simonia (2004, 2007a, 2007b) was presented theoretical model of frozen hydrocarbon particles of icy halo of the comets and the mechanisms of FHP luminescence were discussed. It was proposed that under the influence of solar electromagnetic and corpuscular radiations,

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solid component of comet matter, including ices, icy particles, silicate dust, may exhibit luminescence within the visible spectral range. Photoluminescence of the solid cometary matter will be, in major cases, subject to the Stokes law, and the maximum of the photoluminescence spectrum will be shifted in direction of the long wavelength in relation to the absorption spectrum maximum $\lambda_{\mathrm{lum}} > \lambda_{\mathrm{abs}}$. Simonia (2007b) explained the nature of unidentified emissions, observed in the cometary spectra, as luminescence of frozen hydrocarbon particles of icy cometary halos. Having studied spectra of the comets 122P/de Vico, 23P/Brorsen-Metcalf, 109P/Swift-Tuttle, he proposed, in particular, that for the comets up to 14% of unidentified emission lines represent photoluminescence of FHP. Along with this no less than 86 per cent of unknown emissions remained unidentified. Icy and mineral particles of cometary halo approaching the sun may exhibit luminescence under the influence of the solar X-ray, UV radiation, and the fluxes of high-energy electrons and protons. Solid cometary matter, processing the absorbing ultra-violet radiation of the sun, will emit luminescent photons of smaller energies $E_{\mathrm{lum}} < E_{\mathrm{abs}}$. Registration of cometary solid matter luminescence suggests an opportunity to establish chemical-mineralogical composition and some physical parameters of this matter. In fact 14 per cent of cometary emission lines mentioned above, earlier having the status of unidentified, and now being considered as photoluminescent emissions of FHP, are indicators of chemical composition of icy cometary halos.

Naturally, luminescence of silicate and carbonaceous dust constituting cometary dust halo will also be an indicator of chemical-mineralogical composition and physical properties of mineral particles. Visibility of cometary luminescence is conditioned by high quantum yield of luminescence and law albedo of frozen hydrocarbon particles. The present work describes results of new researches of unidentified cometary emission lines as an indicator of the chemical composition of solid cometary matter.

2 Polycyclic aromatic hydrocarbons—constituent of the cometary solid matter

Cometary spectra, along with emission lines, are also characterized with faint continuum of solar origin. Icy and dust particles of cometary halos, scattering optical solar radiation condition the appearance of such a continuum. Our attention will be concentrated at the complex of unidentified emission lines of cometary spectra.

Polycyclic aromatic hydrocarbons, wide-spread in the universe, are also contained in the substance of comets (Ehrenfreund and Charnley 2000; Clairemidi et al. 2004, 2007; Lisse et al. 2007). It was proposed in the work by Simonia (2007a, 2007b) that the cometary nuclei can contain frozen mixtures of polycyclic aromatic hydrocarbons and alkanes, for example, Phenanthrene + n-hexane or Coronene + n-heptane. As the comet approaches the sun, during intensification of the processes of ice sublimation and mechanical destruction of cometary nucleus surface layers, there takes place ejection of fine-grained icy particles into near-nucleus space. This process, in greater extent, causes formation of icy cometary halos of characteristic size and form. Icy halo of comets also contain fine-grained icy particles consisting of frozen mixture of polycyclic aromatic hydrocarbons and alkanes. Icy particles of such kind can contain additional admixtures as the component of solid solution or mechanical inclusions, for example, inclusions in the form of carbonaceous particles of submicron sizes. Fine-grained icy particles, the matter of which consists of frozen mixture of hydrocarbons (FHP), are contained in the icy halo of comets, characterized by corresponding sizes and form, being micro-fragments of polycrystalline solutions of hydrocarbons—constituent of icy cometary nuclei.

Solar ultraviolet radiation excites photoluminescence of FHP of icy cometary halo. UV photons, absorbed by icy particles matter, re-emit by it in the form of photons of smaller energies within the visible range of the spectrum. Naturally, fluxes of electrons and protons of high energies can also excite luminescence of FHP—the process of cathodoluminescence of icy particles. Spectral composition of FHP luminescence depends on: a) chemical composition of concrete icy particle; b) PAH concentration in the particle matter; c) particle matter temperature; d) presence or absence of additional luminescent admixtures in the particle matter; e) solar activity phase. Complex organic mixtures in conditions of room temperature are characterized by the luminescence spectra in the form of wide structureless bands. Laboratory experiments revealed that: if PAH molecules are dissolved in alkanes at 77 K or low, aromatic molecules will isolated each from other and fixed in the solvent. Such matrix is characterized by luminescence spectra in the form of series of narrow lines—quasi-linear spectra (Schpolski 1962). In cometary ices frozen mixtures of PAHs and alkanes may emit narrow luminescence lines on the specific heliocentric distances were temperature of ices is around 80 K or low. The laboratory data point to the fact that FHP of icy cometary halo can potentially possess: 1. Photoluminescence spectra in the form of wide structureless bands; 2. Photoluminescence spectra containing series of very narrow lines. Existence of Schpolski matrix in cometary ices is highly possible due to low temperature of cometary bodies and numerous organic compounds in cometary substance.

Detectability of photoluminescence emissions of cometary FHP is an important factor. Gudipati et al. (2003) proposed that quantum yield of luminescence of small grains containing organic mixtures variate within 90–100%. These laboratory data point to bright luminescence of organic mixture excited by UV radiation. We calculated for conditions of real cometary halo (FHPs halo), the ratio of flux of luminescence to the flux of scattered solar radiation F_{lum}/F_{scat}. The following conditions were taken: FHP of millimeter size; chemical composition of particles Phenanthrene + n-hexane; albedo of particles $A = 0.1$; FHP luminescence yield $q = 50$ per cent. We calculated mentioned ratio for spectrum ranges with different width and wavelength using values of solar UV and optical fluxes on the distance 1 a.u. obtained from different databases and sources, including Cox (2001). Calculations suggested that for considered FHP of icy cometary halo the ratio F_{lum}/F_{scat} varies within 1.2–4.3. Calculations suggested also that solar UV radiation in range 3000–3800 Å effectively excites cometary FHP luminescence in range 4000–7000 Å. This means that in many cases luminescence signal of FHP lies over scattered solar continuum. This signal represents faint, but quite fixed emission. Such, relatively faint unidentified emissions are widely presented in the catalogue by Brown et al. (1996) and atlas by Cochran and Cochran (2002).

Simonia (2007b) proposed that certain number of unidentified emission lines in the spectra of comets 109P/Swift–Tuttle and 23P/Brorsen–Metcalf are FHP photoluminescence of icy halos.

The work by Cremonese et al. (2007) contains extended catalogue of emission lines of the spectrum of comet 153P/Ikeya-Zhang. In the mentioned catalogue 8468 emission lines are tabled. From this amount 1862 emission lines had the status of unidentified. We conducted comparative analysis of the spectral positions of unidentified emission lines in the spectrum of comet 153P/Ikeya–Zhang with the spectral positions of photoluminescence emission lines of chemical analogues of cometary FHPs in the form of polycrystalline solutions PAH+alkanes. As the laboratory data we used the atlas of quasi-linear spectra of luminescence of aromatic molecules and other materials (Teplitskaia et al. 1978; Nakhimovsky et al. 1989; Rima et al. 1999; Ghauch et al. 2000). The criteria for selection were coincidence of spectral positions of corresponding emission lines within ±1 Å and in similarity of their profiles.

Table 1 shows the results of our comparative analysis. In column 1 are given wavelengths of cometary emission lines (observed lines) having the status of unidentified in the catalogue by Cremonese et al. (2007). Column 2 presents the wavelengths of luminescence emission lines of polycrystalline mixtures (PAH-alkanes) selected from Teplitskaia et al. (1978); Nakhimovsky et al. (1989), Rima et al. (1999) (laboratory data). Column 3 presents names of relevant polycyclic aromatic hydrocarbons and names of relevant aliphatic hydrocarbons—solvents. In result of comparative analysis we have managed to identify 21 molecules

Table 1 Photoluminescent emissions of the cometary spectrum

Observed lines (λ, Å)	Laboratory data (λ, Å)	PAHs and solvents	
4600.98	4601	Perylene	n-hexane
4602.14	4602	Phenantrene	n-hexane
4602.37	4603	3-Methylperylene	n-octane
4609.28	4609	Dibenzo[α,h]Pyrene	n-hexane
4610.09	4610	Perylene	n-hexane
4614.19	4614	3,4–8,9 Dibenzpyrene	n-hexane
4615.39	4615	3-Methylperylene	n-octane
4617.13	4617	Triphenylene	n-hexane
4623.31	4623.3	Perylene	n-hexane
4646.13	4646	Triphenilene	n-hexane
4649.47	4649	Diphenilenoxid	n-hexane
4649.91	4650	Perylene	n-hexane
4706.04	4706	Triphenylene	n-hexane
4719.17	7419	Tetracene	n-hexane
4742.97	4743	1,2–3,4 Dibezpyrene	n-hexane
4763.01	4763	2,3 Ortophenylenepyrene	n-octane
4769.04	4769	Perylene	n-hexane
4769.57	4770	Benzo[j]Fluorantene	n-hexane
4774.25	4774	3-Methylperylene	n-octane
4794.24	4794	Tetracene	n-hexane
4806.56	4807	Dibenzo[α,h]Pyrene	n-hexane
4811.36	4811.65	Benzo[j]Fluorantene	n-hexane
4826.91	4826.6	Benzo[j]Fluorantene	n-octane
4827.40	4827	Perylene	n-hexane
4840.49	4840	3,4–8,9 Dibenzpyrene	n-hexane
4842.12	4842	Pentafene	n-hexane
4849.20	4849	Triphenylene	n-hexane
4858.46	4858	3-Methylperylene	n-octane
4866.80	4866	3-Methylperylene	n-octane
4874.10	4874	Perylene	n-hexane
4874.92	4874.95	Benzo[j]Fluorantene	n-hexane
4890.25	4890	3,4–9,10 Dibezpyrene	n-hexane
4893.46	4893.3	Benzo[j]Fluorantene	n-octane
4897.38	4897	3,4–9,10 Dibezpyrene	n-hexane
4915.23	4915	2,3 Orthophenylenepyrene	n-octane
4925.96	4925	3-Methylperylene	n-octane
4950.46	4950	Benzo[j]Fluoranthene	n-octane
4966.92	4966.6	Benzo[α]Fluoranthene	n-octane
4984.07	4984.3	Benzo[j]Fluoranthene	n-hexane
4985.09	4985	Naphtacene	n-nonane
5025.12	5025	2,3 Orthophenylenepyrene	n-hexane
5028.42	5028	Chrysene	n-hexane
5060.23	5060	Phenanthrene	n-hexane
5086.61	5087	Tetracene	n-hexane
5176.26	5176	Tetracene	n-nonane
5197.20	5197	Tetracene	n-nonane

(*continued on next page*)

Table 1 (*Continued*)

Observed lines (λ, Å)	Laboratory data (λ, Å)	PAHs and solvents	
5218.61	5219	Tetracene	n-hexane
5249.97	5250	9-Hexylphenanthrene	n-hexane
5260.34	5260	Coronene	n-hexane
5318.22	5318	Chrysene	n-hexane
5349.21	5349	1,2 Benzpyrene	n-hexane
5352.10	5352	Chrysene	n-hexane
5366.46	5366	1,2 Benzpyrene	n-hexane
5479.24	5479	1,2 Benzpyrene	n-hexane
5542.36	5542	1,2–5,6 Dibenzantracene	n-hexane
5615.20	5615	Coronene	n-hexane
5629.74	5630	Coronene	n-hexane
5680.20	5680	9-Hexylphenanthrene	n-hexane
5870.04	5870	1,2 Benzpyrene	n-hexane
5894.21	5894	Pyrene	n-hexane
6026.65	6027	Pyrene	n-hexane
6036.40	6036	Pyrene	n-hexane
6096.48	6096	1,2–5,6 Dibenzantracene	n-hexane
6134.99	6135	1,2–5,6 Dibenzantracene	n-hexane
6150.95	6151	1,12 Benzperylene	n-hexane
6276.23	6276	1,12 Benzperylene	n-hexane
6415.16	6415	Tetraphene	n-hexane
6460.05	6460	9-Hexylephenanthrene	n-hexane
6508.74	6509	Pyrene	n-hexane
6638.21	6638	Tetraphene	n-hexane
7029.93	7030	9-Hexylephenanthrene	n-hexane
7810.16	7810	9-Hexylephenanthrene	n-hexane

of polycyclic aromatic hydrocarbons being in the content of FHPs matter of icy halo of comet 153P/Ikeya-Zhang. To these molecules are attributed Phenanthrene, Pyrene, Chryzene, Coronene, etc. Comparative analysis suggested, in particular, that 72 lines of 153P/Ikeya-Zhang spectrum represent photoluminescence emission lines of frozen mixtures PAH+alkanes, being cometary FHP matter. Photoluminescence emission lines, identified by us, made up 3.8 per cent of the total number of earlier unidentified emission lines of the mentioned comet. The rest 96.2 per cent of emission lines still remained in the status of unidentified. These emission lines demand further study considering high probability of their ionic nature.

Thus, icy halo of 153P/Ikeya-Zhang comet contains the complex of frozen hydrocarbon particles icy grains of different forms and sizes emitting luminescence in visual range of the spectrum. In fact, there takes place photoluminescence of FHP in form of phosphorescence and fluorescence with after glowing period $\tau > 0$ and $\tau = 0$, respectively. Luminescence of cometary FHP can be also caused by bombarding by fluxes of fast electrons of solar origin, more

Table 2 Ultraviolet luminescence of the cometary FHP

Unidentified emissions (λ, Å)	Luminescence emissions (λ, Å)	PAHs and solvents	Excitation radiation (λ, Å)
3184	3184	Diphenileneoxid n-heptane	2850
3290	3290	β-Metilnaphtalene n-hexane	3000
3310	3310	Naphtalene n-pentane	3000

because the solid bodies photoluminescence and cathodoluminescence are too much alike, differing only in the means of leading the exciting energy to the corresponding body. The following circumstances attract attention: 1) we have revealed in the spectrum of 153P/Ikeya-Zgang comet photoluminescence emission lines on the wavelengths of 4602.14 Å and 6134.99 Å. Photoluminescence emissions with almost same wavelengths were revealed by us in the spectrum of comet 122P/de Vico (λλ 4602.17, 6135); 2) 5 photoluminescence emission lines of spectrum of 153P/Ikeya-Zhang comet coincide by spectral position with photoluminescence emissions of 109P/Swift-Tuttle and 23P/Bronsen-Metcalf comets spectra. The above-said suggests in favor of similarity of chemical composition of FHP icy halo of the mentioned comets. Thus, frozen hydrocarbon particles of different cometary icy halo, as in general, ices of their nuclei can be too close, similar by chemical composition (under chemical composition we understand composition of mixture PAH+alkanes).

Figures 1 and 2, are showed relevant fragments of 153P/Ikeya-Zhang comet spectra and luminescence spectrum of laboratory analogues of cometary FHP matter in the form of frozen mixture of 3-Methylperylene with n-octane. Attention is attracted by resemblance of profiles of earlier unidentified cometary emission lines with the profiles of luminescence emission lines of frozen matter of the chemical composition mentioned above. Concentration of aromatic molecules in mixture within 10^{-3}–10^{-2} mol L^{-1} provides formation of luminescence quasi-lines and probably detectability of such luminescence in cometary spectra.

If FHPs of icy cometary haloes emit luminescence in visible spectral range, they can also emit luminescence in ultraviolet under the influence of far more shortwavelength electromagnetic solar radiation. With the aim of proving this supposition, we have conducted comparative analysis of spectral position of the unidentified emission lines of some comets presented in the work by Arpigny (1995), with the spectral positions of luminescence emission lines of FHP chemical analogues (Teplitskaia et al. 1978). Unidentified emission lines were positioned within the range of 3180–3315 Å. Obtained results are given in Table 2. In column 1 of the table there are given wavelengths of the unidentified cometary emission lines according to Arpigny (1995);

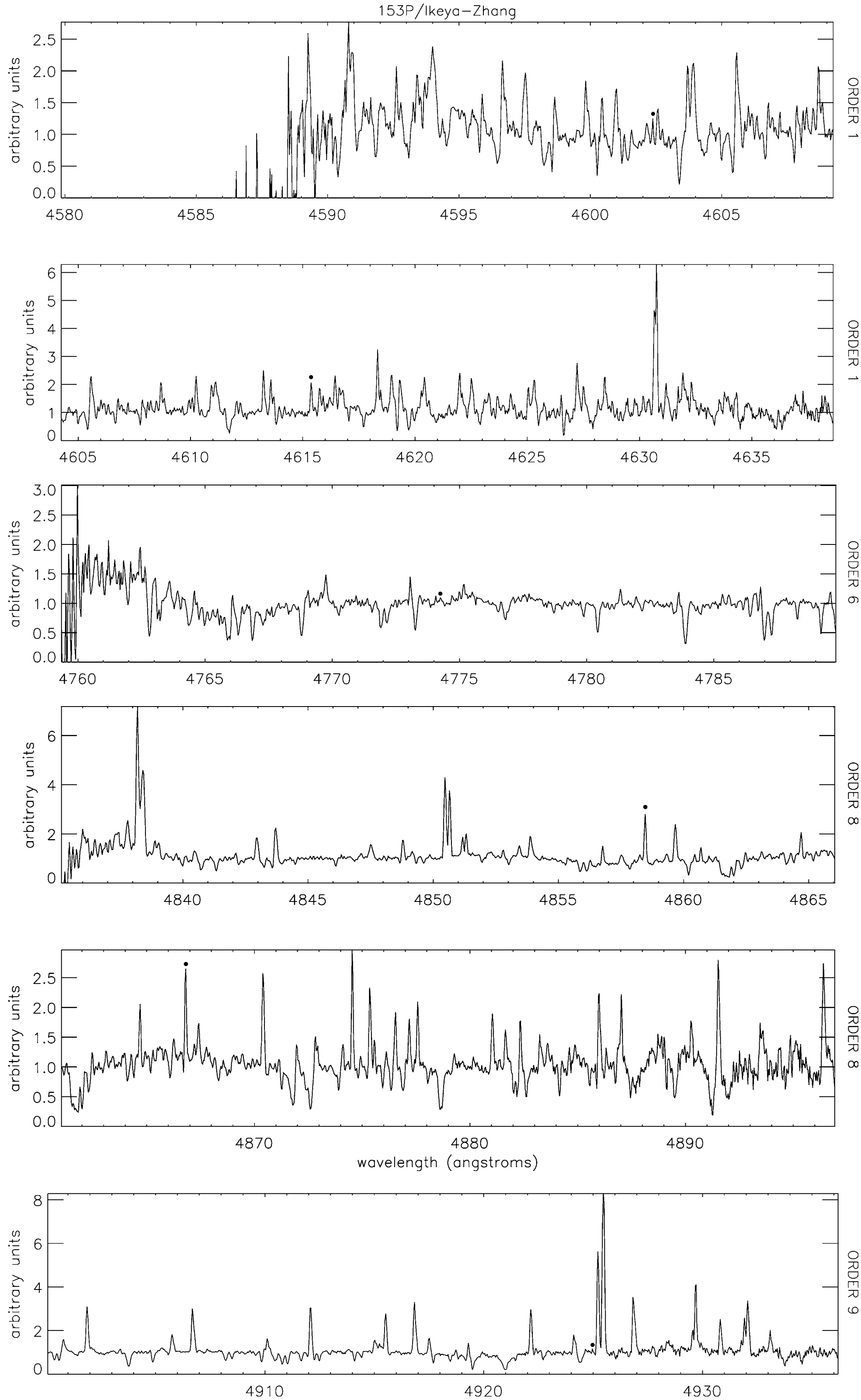

Fig. 1 Fragments of 153P/Ikeya-Zhang comet spectrum obtained by means of 3.5 m TNG telescope and echelle spectrograph SARG, La Palma, Canary Islands, Spain (Cremonese et al. 2007). Emission lines at 4602.377; 4615.39; 4774.250; 4858.467; 4866.808; 4924.960 Å were earlier unidentified. Now we consider them as candidate to luminescence emission lines of frozen hydrocarbon particles of icy cometary halo

in column 2—wavelengths of luminescence emission lines of frozen mixtures PAH+alkanes (Teplitskaia et al. 1978); column 3 gives names of PAHs and names of solvents; column 4 shows wavelengths of exciting radiation. On the basis of comparative analysis we have managed to identify several polycyclic hydrocarbons constituting icy mix-

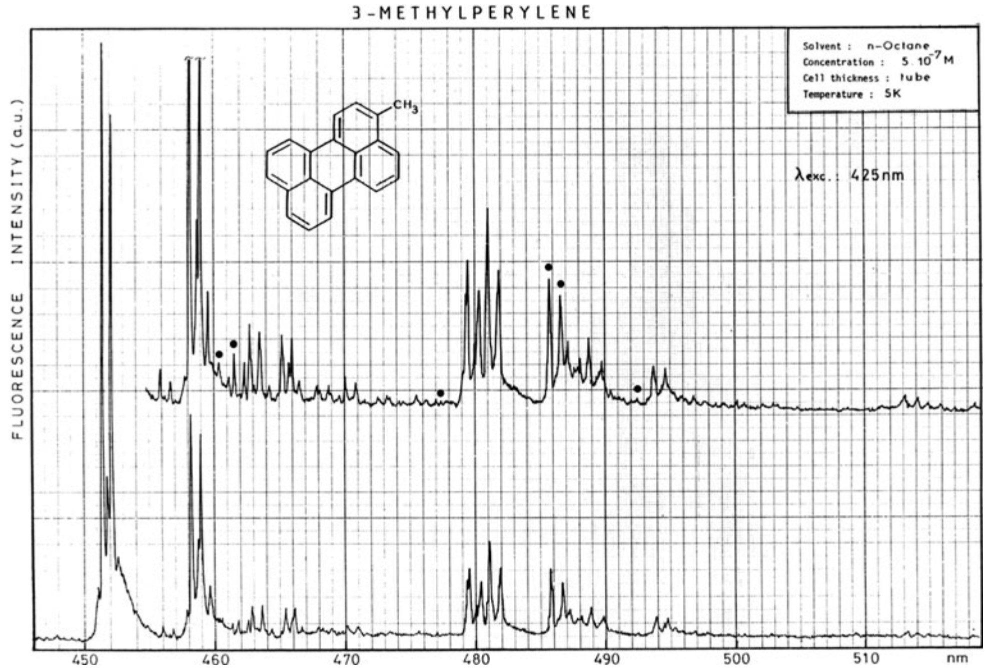

Fig. 2 Fragments of luminescence spectra of frozen mixture 3-Methylperylene and n-Octane (Nakhimovsky et al. 1989). Emission lines at 460.3; 461.5; 477.4; 485.8; 486.6; 492.5 nm coincides in spectral positions and profiles with cometary unidentified emissions (Fig. 1). Different concentration of aromatic molecules in cometary and laboratory samples provides difference of band-width in astronomical and laboratory spectra

ture with corresponding aliphatic hydrocarbons. FHP of the mentioned chemical composition of icy haloes of corresponding comets might be sources of 3 luminescence emission lines in UV spectra of these comets. Thus, hydrocarbon particles of icy cometary halo may luminesce also in UV range.

In the work by Clairemidi et al. (2004) P/Halley comet spectrum has been studied, obtained by the apparatus Vega 2. In particular, UV range of this spectrum has been studied. Emissions 3710 Å; 3760 Å; 3820 Å were identified by the authors of the mentioned work as fluorescence of PAH molecules, namely, Pyrene $C_{16}H_{10}$. The authors of the mentioned work call their identification experimental, preliminary, which requires further confirmation.

We have done comparative analysis of spectral positions of the mentioned UV emission lines of P/Halley comet spectrum (Clairemidi et al. 2004) with the spectral positions of photoluminescence emission lines of frozen mixtures PAH+alkanes—chemical analogues of cometary FHPs. For this, the atlas of luminescence spectra of aromatic molecules was used (Teplitskaia et al. 1978). In result of the comparative analysis it was suggested that emission line 3820 Å is photoluminescence of cometary FHP of frozen mixtures of Pyrene $C_{16}H_{10}$ and n-hexane. Emission lines 3710 Å and 3760 Å remained unidentified. In P/Halley comet spectrum emission 3820 Å possesses noticeable width not characteristic to luminescence emission lines of frozen mixture PAH+alkanes. Such differences of band width probably caused by different phases of substances (fluorescence of PAH molecule in gas phase and luminescence of same frozen PAH).

3 Discussion

We have revealed that from the total number of unidentified emissions of the 153P/Ikeya-Zhang comet spectrum 72 emission lines have photoluminescence nature. Under influence of solar ultraviolet radiation 21 polycyclic aromatic hydrocarbons and alkanes in the form of frozen mixture, constituting icy halo particles matter, may luminesce in the optical spectral range, being source of narrow lines series. Thus, icy halo of this comet abounds in organic compounds in the form of frozen aromatic and aliphatic hydrocarbons. Study of cometary ices luminescence enables to determine their exact chemical composition and, in some cases, the temperature.

Presence of noticeable organic component in the cometary ices in the form of hydrocarbons mixtures witnesses that other icy bodies, including ice-covered bodies (some satellites of giant planets), can luminesce under the influence of shortwavelength solar radiation and fluxes of solar wind charged particles. This means that detection of such luminescence and correct interpretation of the obtained data enable as minimum to determine chemical composition of these bodies.

We have also studied the UV parts of other comet spectra and proposed that a number of unidentified emission lines of the cometary spectra represent UV luminescence of FHP. In laboratory environment spectral parameters of PAH+alkanes luminescence were obtained with the high accuracy (Teplitskaia et al. 1978; Nakhimovsky et al. 1989). Many quasi-lines of luminescence spectra of mentioned solid mixtures are measured with accuracy less than

±1 Å. Using of such comparative lab data is suitable for identification of PAH+alkanes luminescence emissions in cometary spectra. We identified six luminescence emission lines of 3-Methylperylene solved in n-octane in spectra of 153P/Ikeya-Zhang comet (Fig. 1). Other luminescence emission lines of mentioned frozen mixture are not identified in optical spectra of mentioned comet: a) concentration of aromatic molecules in alkanes probably is different in laboratory samples and in cometary icy particles; b) frozen hydrocarbon particles of cometary halos probably consist from complex mixture solid solution of several PAHs in alkanes. In fact, in labs were studied simple specific mixtures PAH in alkanes, while cometary icy matter as natural substance will consist from complex aromatic molecules solved in alkanes. a), b), circumstances probably explain why we are unable to reveal in cometary spectra whole set of laboratory luminescence emission lines of specific frozen mixture. Luminescence spectra of simple PAH+alkane solid solutions will always differ from luminescence spectra of cosmic substance consisted from complex aromatic molecules solved in alkanes. Generally not only UV radiation of the Sun may excites luminescence of cometary FHPs. Visible solar radiation in range 4000–4300 Å may also excites luminescence of icy particles of cometary halos.

It necessary to note, several frozen compounds which luminescence lines are consistent in intensity with respective emission lines of 153P/Ikeya-Zhang comet spectrum, particularly luminescence lines of 3-Methylperylene (460.3, 461.5, 477.4, 485.8, 486.6, 492.5 nm); Dibenzo[a,h]Pyrene (480.7 nm); Benzo[j]Fluoranthene (481.165, 498.43 nm) are consistent in intensity with cometary lines. At the same time not all earlier unidentified lines of 153P/Ikeya-Zhang comet spectrum are consistent in intensity with laboratory luminescence lines of frozen organic mixtures. Differences in: physical conditions (including temperature) of cometary icy matter and laboratory ice; chemical admixtures of cometary and laboratory ices; fluxes of exciting radiations in space and in laboratory might explain mentioned phenomena.

In several cases, frozen hydrocarbons, in laboratory conditions, shows intense luminescence lines which never yet registered in cometary spectra. For example intense luminescence emission lines of perylene (481.9, 506.6 nm); Benzo[j]Fluoranthene (474.66, 482.33 nm) are not observed in 153P/Ikeya-Zhang comet spectrum. Probably chemical peculiarities of specific FHPs of 153P/Ikeya-Zhang comet halo might play an important role in formation and quenching of icy luminescence. We also may assume that mentioned luminescence lines will observable in the spectra of other comets. Generally speaking the problem of intensity of FHP luminescence requires separate studies including exact laboratory measurements and astronomical observations with large optical instruments.

Surface of the icy cometary nuclei can also luminesce under the influence of solar shortwavelength radiation. This may happen only at great heliocentric distances under conditions of cometary halo absence. Instrumental registration of possible luminescence of cometary nuclei will be quite a difficult task, taking into consideration great geocentric distance of "naked" cometary nuclei.

4 Conclusion

We have described peculiarities of FHP photoluminescence of icy cometary halo. Comparative analysis has been conducted of spectral positions of unidentified emissions of 153P/Ikeya-Zhang comet spectrum given in the work by Cremonese et al. (2007) with luminescence emissions of FHP analogues given in the works by Teplitskaia et al. (1978), Nakhimovsky et al. (1989). 72 emissions of 153P/Ikeya-Zhang comet spectrum were proposed as photoluminescence of icy halo of this comet and 21 polycyclic aromatic molecules as component of FHPs of icy cometary halo. Luminescence of cometary FHP in UV range was revealed. Further research of luminescence of cometary icy particles can become an efficient "tool" for obtaining exact data on origin and evolution of the comets.

Acknowledgements The author expresses his gratitude to Prof. M. Dopita for the valuable discussion.

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