21. LIGHT OF THE NIGHT SKY (LUMIERE DU CIEL NOCTURNE)

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I. INTRODUCTION

The different components of the light of the night sky have their origin in different formations of matter in the universe - encompassing a huge scale of distances ranging from a few kilometers in the earth's atmosphere to the most distant known galaxies and beyond. Correspondingly, the borderlines to other Commissions are not very well defined and thus material relevant to Commission 21 can also be found in the reports of other Commissions on the following topics: zodiacal light and zodiacal IR emission (Comm. 22, 44), integrated starlight (33, 25), diffuse galactic light (34), extragalactic background light (47), airglow and atmospheric scattered light (50), and space-borne observations of the LONS (44). From the Commission 21 point of view the connecting link between these various fields is the special techniques utilized in the surface photometric measurements and reductions of background radiations which extend over the entire sky. One crucial problem is the separation of the LONS into its several components. The approach for solving this task is to utilize the different spatial distributions and different broad and narrow band spectral properties of each of the LONS component. Thus the successful measurement and separation of one of the LONS components requires a knowledge of the properties of all the other components. This situation has become apparent in recent years as the infrared background radiation database, provided by the Infrared Astronomical Satellite (IRAS), has been analyzed: both the zodiacal and galactic dust emissions have to be analyzed hand in hand, and both these components must be very accurately mastered before any conclusions are possible on the extragalactic component. It is also obvious that very similar problems are encountered in the ultraviolet and infrared wavelength regions as in the more traditional optical domain. Thus the techniques developed in one of these wavelength domains are directly applicable in the others.

Knowledge of the sky brightness is also important when trying to push the detection limit for very faint objects - either extended or pointlike - to the utmost possible from ground or space. For this purpose the selection of the most suitable low-background windows, either at special positions on the sky or in special wavelength regions of the spectrum, can be selected. It has even become possible to take the measuring instrument itself to a special favorable place in the solar system: thus the orbit of the Helios sunprobe, which reached 0.3 AU in the perihel, enabled the measurement of the zodiacal light and thus the distribution of the interplanetary dust in dependence of the distance from the Sun. Equally important have been the LONS measurements from the outbound orbits of Pioneer 10 and 11. Beyond the asteroid belt (r ≥ 3.3 AU) the zodiacal light vanished and a measurement of the sum of the pure galactic and extragalactic LONS components was possible without any foreground contamination. Unfortunately, with the cancellation of the US-spacecraft for the Out-of-Ecliptic Solar Polar Mission (ISPM) we lost the unique opportunity to obtain photopolarimetric measurements of the LONS from a position out of the ecliptic plane.

At the beginning of the triennium covered by this report the IAU Colloquium No. 85 "Physical Properties and Interactions of Interplanetary Dust" was organized by Commission 21. The proceedings of this meeting, with R.H. Giese and P. Lamy as editors, have been published in 1985 by D. Reidel, Dordrecht, as Volume 119 of the Astrophysics and Space Science Library. The proceedings include 80 reviews and contributed papers providing an up to date presentation of our knowledge of the zodiacal dust cloud.

This report was prepared with the help of many Commission members who provided information on their recent research. The task of writing the report was divided between Dr. A.C. Levasseur-Regourd (Airglow and zodiacal light) and the undersigned.

We have found it convenient to use the following very abbreviated references to which we provide the key here:

A & A = Astron. Astrophys.
A & A Sup = Astron. Astrophys. Suppl.Ser.
AdvSpaRes = Advances in Space Research
AJ = Astron. J.
AnnRevA&A = Ann.Review of Astron. Astrophys.
ApJ = Astrophys. J.
ApJ Sup = Astrophys. J. Suppl. Ser.
ApSpaSci = Astrophys. Space Science
BAAS = Bull. American Astron. Society
MN = Mon. Not. R. Astr. Soc.
Mitt. Astron. Ges. = Mitteilungen der Astron. Gesellschaft
PASP = Publ. Astron. Soc. Pacific
JGG = J. Geomagn. Geoelectr.
JGR = J. Geophys. Res.

In addition, IAU Symposium and Colloquium volumes are referred to by IAU Symp or IAU Coll and the appropriate number.

The following common abbreviations referring to the Light of the Night Sky (LONS) have also been used:

DGL = Diffuse Galactic Light
EBL = Extragalactic Background Light
ISL = Integrated Starlight
"unit" = photons cm^{-2} s^{-1} sr^{-1} Å^{-1}

II. LONS, OBSERVING SITES AND FAINT SOURCE DETECTION LIMITS

A comparison of the night sky surface brightness (optical and UV) at excellent ground-based sites to the sky background in space has been presented by O'Connel (1987,AJ in press). Garstang (1986 PASP 98,364) has set up a model to permit prediction of the brightness of the night sky caused by the scattering of city light. Pilachowski et al. (1987 BAAS 19, 750) report on a systematic monitoring of the night sky brightness at Kitt Peak and Payne (1985 Proc. Astron. Soc. Australia 6, 182) at three observatory sites in Australia. Klimik and Shvalagin (1985 Astron. Tsirk. No. 1370, p.5) have investigated the determination of artificial sky background contamination.

III. AIRGLOW

(A.C. Levasseur-Regourd)

Numerous papers on the airglow have been published in the triennium and are likely to be included in the category of geophysics (theoretical modelling, reaction rate coefficients, lines profiles...). It should nevertheless be pointed out that airglow measurements made both from earth-based or space observatories are of major interest for astronomical observations. They provide information on the light pollution or on the fluctuations of the airglow (Meinel IR bands...) and set limits on the integration time for observations performed from space platforms in low Earth orbit.

Earthbased observations. An atlas of zenith airglow radiation (Kiso, 1979-1983) has been published by Tanabe. Spectra at the north ecliptic pole (Pic du Midi Obs.) have been analysed by Louistisserand et al. (A & A Sup 68, 539). Airglow studies in India have been presented by Agashe (Indian J. Radio & Space Phys. 16,84). Airglow variations related to seismic activity have been reported by Fishkova et al. (Ann. Geophys. 3, 689).

Space observations. Rocket airglow observations have been reported by Ogawa et al.(J. Geomagn. Geoelectr. 39, 211) and Lopez-Moreno et al.(Ann. Geophys. 2, 61 and JGR 90, 6617). UV airglow observations obtained during morning twilight and near midnight rocket flights have been analysed (Cebula & Feldman, JGR 80, 9080 ; Tennyson et al., JGR 91, 10141). Also UV nightglow has been monitored from the UVX experiment on board the space shuttle (Feldman et al., EOS Trans. Am. Geophys. Union 68, 373).

IV.ZODIACAL LIGHT

(A.C. Levasseur-Regourd)

Dramatic progress has been achieved in our knowledge of zodiacal dust, through analyses of ground-based or space zodiacal light observations, and through modelling of the zodiacal dust (Leinert & Staude, ApSpaSci 116, 415). During the last triennium, a significant number of contributions have been published in the proceedings of IAU Coll. 85, Properties and Interactions of Interplanetary Dust (= PIID) ; also major advances have been triggered by cometary dust observations and by IRAS observations of the thermal emission of the zodiacal cloud.

Zodiacal light observations

General observations. Further analyses of observations performed on board Pioneer 10 spaceprobe (Toller & Weinberg, PIID, 21), D2B spacecraft (Maucherat et al., PIID, 27), or Salyut 7 space station (Levasseur-Regourd et al., AdvSpaRes 5, No3, 27 ; Nikolsky et al., PIID, 7) have been presented. Also Dopplershifts have been measured (East & Reay, PIID, 81 ; Robley et al., PIID, 85), and surface brightness maps have been provided (Misconi & Weinberg, PIID, 11 ; Pfleiderer & Leuprecht, PIID, 17).

The thermal emission of the dust has been monitored by IRAS spacecraft ; it is indeed the most prominent component of the sky at 12 and 25 μm (see Proc. 1^{rst} IRAS Conf., Light on Dark Matter) ; it has also been observed during rocket and balloon flights (Murdock & Price, AJ 90, 375 ; Salama et al., AJ 93, 467). As emphasized in the review given by Weinberg (PIID, 1), recent results present a more complex picture of the zodiacal cloud than what was anticipated before ; mainly due to the infrared IRAS observations, it is confirmed that the cloud is neither completely smooth, nor really homogeneous.

Inner zodiacal light. A review on the F-corona and circumsolar dust has been presented by Koutchmy & Lamy (PIID, 63). The Zodiacal light experiment on board Helios B has been used to image solar mass ejection transients in the interplanetary medium (Jackson & Leinert, JGR 90, 10759).

Dopplershifts have been measured during the July 31, 1981 solar eclipse ; a prograde keplerian motion was found (compatible with grains with radii ~ 0,4 μm), as well as some retrograde motion (dust injected by Kreutz group comets ?) ; also a local stream (β meteoroids ?) was detected near the north coronal hole (Shcheglov et al., PIID, 77 ; Shcheglov et al., A & A 173, 383 ; Shestakova, A & A 175, 289). From the balloon observations performed during the June 11, 1983 solar eclipse, polarization degrees of inner zodiacal cloud were estimated, near IR photometry was performed, and an excess in infrared brightness (hot dust cloud ?) was noticed ; (Isobe et al., PIID, 49 ; Maihara et al., PIID, 55 ; Tanabe et al., AdvSpaRes 5, No1, 69).

Gegenschein. Pictures of the Gegenschein have been derived from D2B data ; temporal variations in intensity and morphology were found ; they could be associated to cometary or asteroidal debris (Maucherat et al., A & A 167, 173). Observations from Pioneer 10 also confirm the existence of small amplitude spatial fluctuations of the brightness distribution in the Gegenschein region ; a search for such structures is also made in ground based observations (Hong et al., PIID, 33).

Small scale structures. Besides the Gegenschein region, the Schuerman dust arcs region has been tentatively investigated - when observable - for small scale structures (Giovane et al., PIID, 33). From the IRAS zodiacal emission (mainly at 12 and 25 μm), it has been confirmed that the zodiacal cloud is not smooth (Low et al., ApJ 278, L 19).

Two pairs of emission bands seem to circle the ecliptic, each band being ~ 5 % of the strength of the zodiacal emission near the ecliptic ; the colour temperature implies a heliocentric distance of 2.2-3.5 AU. A disrupture collision of a ~ 10 km asteroid could produce enough particles to account for a set of bands, with a time scale for formation and dissipation of a few million years ; the EOS, Koronis and Themis families have been identified as possible progenitors (Dermott et al., PIID, 395 and Asteroids, Comets, Meteors II, 583 ; Sykes & Greenberg, Icarus 65, 51).

Symmetry surface. Annual oscillations in the brightness at the ecliptic poles have been observed by IRAS, together with asymmetries in the brightness profiles ; such features had been found in the optical domain and are also visible in rocket infrared observations (Hauser et al., PIID, 43 ; Winckler et al., A & A 143, 194 ; Murdock & Price, AJ 90, 375). Both the oscillations and the asymmetries are due to the inclination of the symmetry plane upon the ecliptic and, secondarily, to the eccentricity of the Earth's orbit (Hauser & Houck, 1^{rst} IRAS Conf., 39 ; Levasseur-Regourd & Dumont, AdvSpaRes, 6,No7, 87 ; Deul & Wolstencroft, A & A, in press).

A critical review of the different values obtained for the symmetry plane parameters has been made by Dumont & Levasseur-Regourd (1987, Prague IAU meeting). There is, between the various authors, a fairly good agreement at 1 AU on $i \sim 1.5°$, while Ω is found to vary between 50° and 100°. It is generally agreed that the symmetry plane is warped and that there is a systematic variation of the parameters as one moves outward from the Sun, whence the name Symmetry surface ; it is likely that the zodiacal cloud is not a simple axisymmetric volume.

Interpretation of measurements

As seen above (fluctuations at Gegenschein, oscillations at the ecliptic poles), the observations are interpreted in terms of physical properties and spatial distribution of the dust. Interpretations are made possible by fitting general models with observations or, better, by deriving local properties from inversion methods ; various methods have been developed by Hong (PIID, 215 ; A & A 146, 67), Dumont & Levasseur-Regourd (PIID, 207 ; Planet. Space Sci 33, 1) or Lamy & Perrin (A & A 163, 269). By inversion of recent infrared observations, Dumont & Levasseur-Regourd have found a heliocentric fall of the dust local temperature in $r^{-0.3}$, which conflicts with a grey-body assumption near the Earth's orbit (A & A, in press). Also scattering properties of the grains have been extensively studied from laboratory work and theory.

Albedo of the grains. Levasseur-Regourd & Dumont have applied their inversion method (nodes of lesser uncertainty) to infrared observations and concluded that the emissivity of the dust increases, i.e. that its albedo decreases between 0.5 and 1.5 AU (C.R.Acad.Sci., Ser II, Tom. 300, 109 ; AdvSpaRes 6,No7, 87). Decreasing albedo was suggested by Fechtig to explain discrepancies between optical and impact measurements of Pioneer 10 (AdvSpaRes 4, No9, 5) ; it has also been considered by Lumme et al. (Icarus 62, 54) and recently been confirmed by Hong. Mukai et al. have computed that sublimation and sputtering by the solar wind produce "brighter" cometary/zodiacal grains with time, as they spiral towards the Sun (A & A 167, 364).

Distribution of the dust in the ecliptic. The distribution has been investigated in terms of steady state distribution under Poynting - Robertson effect and Lorentz forces ; for grains with radii ~ 30 μm, the heliocentric dependence is found to be ~ $r^{-1.3}$ (Mukai & Giese, A & A 131, 355). Also, it appears that debris from disrupted meteors (cometary or asteroidal origin) would be able to balance the mass loss due to Poynting - Robertson effect and collisions, and could result in a $r^{-1.3}$ distribution (Leinert, PIID, 374 ; Grün et al., Icarus 62, 244). The zodiacal dust dynamics has been studied further, taking into account the planetary perturbations (Gustavson & Misconi, Icarus 66, 280). Local velocities have been inferred from Dopplershift measurements ; the velocity is nearly circular by 0.5 - 1.0 AU, while an excess over the keplerian velocity (radial escape ?) is found by 1.5 AU (Dumont & Levasseur-Regourd, PIID, 207).

Anyhow, the heliocentric decrease of the albedo as mentioned above invalidates the homogeneity of the cloud. The observed change of brightness $r^{-2.3}$, interpreted up to now as a $r^{-1.3}$ change of density, could be partly due to the fall of the albedo, while the fall of density could be in r^{-1} (Dumont & Levasseur-Regourd, 1^{rst} IRAS Conf., 46). This result is in agreement with the analysis made by Hong & Um, using Henyey-Greenstein functions to represent the mean scattering phase function (Ap. J., 320, 928).

Spatial distribution of the dust. Lamy and Perrin have inverted intensity and polarization observations, with the usual r^{-n} power law for the dust number density ; they found that the modified fan model is compatible with the data if the volume scattering function and the local polarization depend upon the heliocentric distance of the observer, but are independent of the latitude (PIID, 239 ; A & A 163, 269). Comparative studies of some 3 dimensional models of the zodiacal cloud have been made by Giese et al. (PIID, 255 ; Icarus 68, 395). The multilobe models (Buitrago) are in strong contradiction with inner zodiacal light observations, while the sombrero type models (Dumont) provide a satisfying fit ; also it is found that the dust spatial density decreases by ~ 2 above the Earth's orbit within 0.2-0.3 AU and that, beyond ~ 1.5 AU off the ecliptic, no reliable density values have yet been obtained from zodiacal light observations.

Laboratory measurements. A review on the different methods to determine the scattering properties of the dust has been given by Zerull, with emphasis on future experiments needed for the interpretation of polarization and colour effects (PIID, 197). A laser-particle dynamics laboratory has been developed in Gainesville to study dust particles light scattering properties for roughened surface spheres and irregular particles (Gustavson et al., Icarus, in press). Microwave analog measurements have been continued at Bochum and Gainesville with irregular or elongated particles (Weiss-Wrana et al., PIID, 219, 223 ; Gustavson, PIID, 227). Also laboratory measurements have been performed in Marseilles with a nephelometer type experimental device (Bliek et al., PIID, 231), together with theoretical studies of the optical properties of rough grains (Perrin & Lamy, PIID, 245).

V. GALACTIC COMPONENTS

Optical. Blue and red isophotes of the galactic background light near the celestial, ecliptic and galactic poles have been presented by Toller et al. (1987, A & A in press). The data were obtained by the Pioneer 10 imaging photopolarimeter from beyond the asteroid belt and are practically free of zodiacal light contamination. After subtraction of the ISL (star counts) an average DGL+EBL contribution of 22 $S_{10}(V)_{G2V}$ remains at the ecliptic and celestial poles. As a continuation of their p.g. UBVR surface photometry Winkler et al. (1984 A & A Sup 58, 705) present a U map of the whole Milky Way which is a compilation of a p.g. northern and a p.e. southern survey. The Pioneer 10 blue and red background starlight data have been analyzed in terms of a Galaxy model by van der Kruit (1986 A & A 157, 230). Important independent information on the photometric parameters of the old disk population has been obtained and compared with external galaxies.

A review of the diffuse galactic line emission in Hα, [N II] λ6583 and [S II] λ6716 has been presented by Reynolds (1984, IAU Coll. 81, p. 97). Observations at high galactic latitudes by Reynolds (1984, ApJ 282, 191) suggest that diffuse Hα extends over the entire sky. Another high-latitude diffuse Hα survey has been started by Münch and Pitz at the Calar Alto Observatory (1987 Mitt. Astron. Ges. 68, 168). Further Hα studies of Milky Way regions have been reported by Reynolds (1986 BAAS 18, 1023) and Brinkman et al. (1986 BAAS 18, 1036). Extended [S II] λ6716 emission has been observed and analyzed and [O III] λ5007 detected by Reynolds (1985 ApJ 294, 256; ApJ 298, L27).

Ultraviolet. A review of diffuse UV continuum and line observations has been presented by Jakobsen (1986, AdvSpaRes 6,No.7,59). The absolute intensity and spatial fluctuations of the UV background between 1450 and 2420 Å have been measured with a large (95 cm) rocket-borne telescope by Jakobsen et al. (1984, A & A 139, 481) along a 50°5 scan path at b ≈ 50°. Significant spatial fluctuations were observed and they were found to correlate with the HI column densities. The observed UV surface brightnesses were found to be in reasonable quantitative agreement with calculations of light scattering by high-latitude dust illuminated by galactic plane stars. Observations with the Berkeley EUV/FUV Shuttle Telescope by Hurwitz et al. (1986, AdvSpaRes 6, No. 7, 69) indicate a good correlation between UV brightness (1400-1800 Å) and HI column density, with a slope which is consistent with the dust scattering parameters obtained earlier from OAO-2 data by Witt and Lillie. Preliminary results from the Hopkins XUV Shuttle experiment by Henry et al. (1986, BAAS 18, 1023) are consistent with the previous results of this group that the UV background is ≦ 300 units (= photons $cm^{-2}\ s^{-1}\ sr^{-1}\ Å^{-1}$) everywhere above $|b| \geqq 20°$. Approximately two-thirds of the celestial sphere were scanned in the 911-1050 Å band with a 10° FOV photometer on board the STP72-1 satellite (Opal and Weller, 1984, ApJ 282, 445). The observed flux was well represented by star catalog integrations.

Discovery of diffuse extended line emission from C IV λ1550, [O III] λ1663 and O VI/Si IV λ1400 were reported by Martin and Bowyer (1986, BAAS 18, 1036; AdvSpaRes 6, No. 7, 79). Spectroscopic observations of the EUV background in the 80-650 Å band were reported by Labov and Bowyer (1986, AdvSpaRes 6, No. 7, 73).

Resonance scattering of solar radiation in the Lyα and HeI λ584 lines of the interstellar wind gaseous component has been reviewed by Bertaux (1984, IAU Coll. 81, p. 3). New results have been presented for hydrogen and helium densities based on Pioneer 10 and Voyager 2 observations in the r > 5 AU region (Shemansky et al. 1984, IAU Coll. 81, p. 24) and on Venera 11 and 12 observations in the inner Solar System (Chassefière 1986, A & A 160, 229). Holberg (1986, ApJ 311, 969) has reported detection of resonance scattering in Lyγ using a very long exposure spectrum from Voyager 2.

Infrared. The galactic infrared background emission was measured by IRAS over 96 % of the sky at 12, 25, 60 and 100 μm. The emission is believed to be thermal reradiation by dust grains (see, however, Harwit et al. 1986, Nature 319, 646 for an alternative). Many aspects of the IR background measurements are covered by the three IRAS conference proceedings:
Light on Dark Matter, ed. F.P. Israel, Reidel, Dordrecht 1986,
Star Formation in Galaxies, ed. C.J. Lonsdale, NASA Print. Off., Washington 1987,
Comets to Cosmology, 3rd Int. IRAS Conf., July 6-10, 1987, Queen Mary College, London,
and the review article by Beichman (1987, AnnRev A&A 25, 521).

The separation of the zodiacal and galactic emission components has been discussed by Jongeneelen et al. (1987, A & A in press), Hauser (1987, in Comets to Cosmology), Rowan-Robinson (1987 ibid.) and Reach and Heiles (1987 ibid.).

The large scale distribution and properties of dust in the galactic disk as derived from IRAS and other IR data and the connections to star formation have been discussed by Burton et al. (1986, in Light on Dark Matter, p. 357), Puget (1985, in Birth and Infancy of Stars, ed. R. Lucas et al., North-Holland, Amsterdam, p. 77), Mezger (1985, ibid. p. 31), Cox et al. (1986, A & A 155, 380), Little and Price (1985, AJ 90, 1812), Caux et al. (1984, A & A 137, 1; 1985, A & A 144, 137) and Caux and Serra (1986, A & A 165, L5).

The near-IR radiation of the Galaxy is due to direct and scattered stellar radiation. A 2.4 μm surface photometry of the galactic center area has been carried out by Hiromoto et al. (1984, A & A 139, 309). A model for the distribution of stellar radiation in the Galaxy at 2.4 μm and in optical (B and V) has been presented by Oda (1985, A & A 145, 45). A similar model has been constructed by Garzon et al. (1986, A & A 155, 63) and has been compared with 2.2 μm star counts and a 2.4 μm surface photometry of the galactic centre area.

The infrared background emission at high galactic latitudes shows, besides a general cosec(|b|) dependence, large spatial fluctuations over scale lengths of tens of degrees down to the 2' resolution limit of IRAS. The name "infrared cirrus" was introduced by Low et al. (1984, ApJ 278, L19) for these structures. Reviews of the infrared cirrus have been presented by Gautier (1986, in Light on Dark Matter, p. 49) and Puget (1987, in Comets to Cosmology). Surprisingly, the cirrus was visible not only at 60 and 100 μm but also at 12 and 25 μm, where colour temperatures of several hundred K are observed (Leene 1985, A & A 154, 295; Boulanger et al. 1985, A & A 144, L9). Very small grains (r << 0.01 μm), transiently heated by single UV photons (Draine and Anderson 1985, ApJ 292, 494) and macromolecules called polycyclic aromatic hydrocarbons (PAH's) have been invoked as explanation (Puget et al., A & A 142, L19; Léger and Puget 1984, A & A 137, L5).

Infrared cirrus is closely linked to the previously observed extended bright optical nebulae at high latitudes (see e.g. Lynds 1965, ApJ Sup 12, 163) and the fluctuations of the UV background radiation, both of which are understood in terms of scattering of ambient stellar radiation by high latitude dust clouds. Detailed comparisons between infrared and optical cirrus have been presented by de Vries and Le Poole (1985, A & A 145, L7) and Laureijs et al. (1987, A & A 184, 269). Also the UV background fluctuations are correlated with infrared cirrus (Jakobsen et al. 1987, A & A 183, 335).

VI. EXTRAGALACTIC COMPONENTS

A review of the extragalactic background radiation, including a detailed discussion of the visible-infrared EBL observations, has been presented by Wilkinson (1984, Proc. 1st ESO-CERN Symp., eds. Setti and van Hove). Paresce (1985, Il Nuovo Cim. 8, 379) has presented a review of both the observational and theoretical aspects of the ultraviolet radiation of cosmological origin. A review of the theoretical aspects ranging from gamma rays to radio waves has been given by Narlikar (1983, 18th Int. Cosmic Ray Conf., eds. Dugaprasad et al., Vol. 12, p. 1).

Optical. Galaxy counts down to the faintest limiting magnitudes attainable today ($\sim 27^m$ in J) have been used by Tyson (1987, Proc. Vatican Conf. on Theory and Observational limits in Cosmology) to estimate an EBL lower limit of 0.43 S_{10} (J) as due to resolved galaxies.

Ultraviolet. In the ultraviolet new upper limits to the extragalactic background have been set: Bixler et al. (1984, A & A 141, 422) give 9700 units at 1040-1080 Å, Opal and Weller (1984, ApJ 282, 445) 7800 units in the 912-1050 Å region, Holberg (1986, ApJ 311, 969) gives limits of 100-200 units in the 500-1200 Å region, and Henry et al. (1986, BAAS 18, 1023) as low as 150 units in some directions at ~1800 Å.

The current limits and prospects of improvement of the UV background radiation data relevant to the detection of radiative decay of fundamental particles have been reviewed by Bowyer and Malina (1986, in Inner Space/Outer Space: The Interface between Cosmology and Particle Physics, ed. Kolb et al., Chicago U.P., p. 512). A break at 1680 Å was claimed by Bochicchio et al. (1984, Proc. 4th Europ. IUE Conf., ESA SP-218, 503) in IUE background data but its statistical significance was questioned by Murthy and Henry (1987, Phys. Rev. Lett. 58, 1581). Holberg's results from Voyager UV spectrometer observations (1985, ApJ 292, 16) place lower limits on the radiative-decay lifetime of massive neutrinos.

Infrared. Boughn and Kuhn (1986, ApJ 309, 33) have searched for the EBL at 6500 Å and 2.2 μm by comparing the sky brightness in the opaque dark cloud L134 and a nearby transparent region. Upper limits on the order of $\nu I_\nu < 10^{-5}$ and $< 10^{-4}$ erg s $cm^{-2}s^{-1}sr^{-1}$ at 6500 Å and 2.2 μm, respectively, were obtained. Boughn et al. (1986, ApJ 301, 17) have also determined upper limits to sky background fluctuations at 2.2 μm. Another near-infrared search has been performed by Matsumoto et al. (1987, preprint; IAU Symp. 124, 69; 1987, Sendai Astr. Rap. 313, 199). The authors attribute the observed isotropic residual component at 2.2 μm of $1.1 \cdot 10^{-4}$ ergs $cm^{-2}s^{-1}sr^{-1}$ to be possibly of extragalactic origin.

In the far infrared domain IRAS data have been utilized by Rowan-Robinson (1986, MN 219, 737) to estimate the extraglactic component to be 5-6±2.5 MJy sr^{-1}. Differential methods for measuring the far infrared background have been discussed by Ceccarelli et al. (1984, in Clusters and Groups of Galaxies, ed. F. Mardirossian et al., D. Reidel, p. 277; 1985, Il Nuovo Cimento 8, 353).

Theoretical. A rediscussion of Olbers' Paradox has been presented by Wesson (1986, ApSpaSci) and Wesson et al. (1986, ApJ 317, 601). They conclude that the reason why EBL is low is the limited lifetime of galaxies and only to a small factor the expansion of the universe.

Calculations on the intensity, spectrum and large scale anisotropies of a cosmological IR background have been presented by Bond et al. (1986, ApJ 306, 428), de Bernardis et al. (1985, ApJ 288, 29), Fabbri et al. (1987, ApJ 315, 12), Guagzhong and Mengxian (1986, Acta Astrophys. Sin. 6, 266) and Negroponte (1986, MN 222, 19).

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