

# The extragalactic background light revisited and the cosmic photon–photon opacity (*Corrigendum*)

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**Key words.** cosmic background radiation – diffuse radiation – gamma rays: galaxies – BL Lacertae objects: general – errata, addenda

For some unexplained reasons, all tables in the [Franceschini & Rodighiero \(2017\)](#) paper have been mixed up. Tables 1–3 reported there were identical to those published in [Franceschini et al. \(2008\)](#). We report here in Tables 1, 2, and 4 the corresponding correct values in terms of photon proper number densities and photon–photon optical depths as a function of photon energy.

We also took this occasion to add a new table (Table 3) including the predicted extragalactic background light values at redshifts between 2 and 3.5, as requested by some readers of the [Franceschini & Rodighiero \(2017\)](#) paper.

Both photon number densities and photon–photon optical depths are calculated including the contributions of the

cosmic microwave background assumed as a black-body with  $T = 2.728$  K. Except for the numerical values in the tables, all the rest of the [Franceschini & Rodighiero \(2017\)](#) paper is unaffected by the problem.

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## References

- Franceschini, A., & Rodighiero, G. 2017, [A&A 603, A34](#)  
Franceschini, A., Rodighiero, G., & Vaccari, M. 2008, [A&A, 487, 837](#)

**Table 1.** Photon proper number density as a function of redshift (1).

$z = 0$		$z = 0.2$		$z = 0.4$		$z = 0.6$		$z = 0.8$		$z = 1.0$	
$\log \epsilon^a$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})^b$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$
-2.8834	2.0525	-2.8042	2.2108	-2.7873	2.4598	-2.7294	2.5758	-2.6782	2.6781	-2.6325	2.7695
-2.8334	1.9065	-2.7542	2.0648	-2.7372	2.3447	-2.6793	2.4607	-2.6281	2.5630	-2.5824	2.6544
-2.7834	1.7255	-2.7042	1.8838	-2.6872	2.1987	-2.6293	2.3147	-2.5781	2.4170	-2.5324	2.5084
-2.7334	1.5035	-2.6542	1.6618	-2.6372	2.0177	-2.5793	2.1337	-2.5281	2.2360	-2.4824	2.3274
-2.6834	1.2365	-2.6042	1.3948	-2.5872	1.7957	-2.5293	1.9117	-2.4781	2.0140	-2.4324	2.1054
-2.6334	0.9185	-2.5542	1.0768	-2.5372	1.5287	-2.4793	1.6447	-2.4281	1.7470	-2.3824	1.8384
-2.5834	0.5435	-2.5042	0.7018	-2.4872	1.2107	-2.4293	1.3267	-2.3781	1.4290	-2.3324	1.5204
-2.5334	0.1839	-2.4542	0.3553	-2.4372	0.8694	-2.3793	0.9885	-2.3281	1.0922	-2.2824	1.1834
-2.4495	-0.2972	-2.3703	-0.0893	-2.3034	0.0803	-2.2454	0.2179	-2.1942	0.3140	-2.1485	0.3790
-2.3034	-0.3062	-2.2242	-0.0961	-2.1573	0.0722	-2.0993	0.2005	-2.0481	0.2751	-2.0024	0.3130
-2.1359	-0.2983	-2.0567	-0.1042	-1.9897	0.0584	-1.9318	0.1752	-1.8807	0.2245	-1.8348	0.2330
-2.0516	-0.3699	-1.9722	-0.1809	-1.9055	-0.0251	-1.8474	0.0803	-1.7964	0.1126	-1.7506	0.1011
-1.9469	-0.4803	-1.8677	-0.2979	-1.8008	-0.1489	-1.7428	-0.0542	-1.6916	-0.0391	-1.6459	-0.0719
-1.8598	-0.7073	-1.7804	-0.5333	-1.7135	-0.3934	-1.6556	-0.3186	-1.6045	-0.3227	-1.5586	-0.3554
-1.7804	-0.8955	-1.7014	-0.7282	-1.6343	-0.5962	-1.5764	-0.5232	-1.5252	-0.5245	-1.4795	-0.5541
-1.7506	-0.9674	-1.6714	-0.7981	-1.6045	-0.6645	-1.5464	-0.5875	-1.4953	-0.5834	-1.4495	-0.6068
-1.6836	-1.1025	-1.6045	-0.9374	-1.5375	-0.8060	-1.4795	-0.7307	-1.4283	-0.7284	-1.3826	-0.7542
-1.5075	-1.5699	-1.4283	-1.3836	-1.3614	-1.2438	-1.3034	-1.1540	-1.2523	-1.1288	-1.2065	-1.1364
-1.3826	-1.7910	-1.3034	-1.6185	-1.2364	-1.4717	-1.1785	-1.3804	-1.1273	-1.3503	-1.0816	-1.3479
-1.2857	-1.8824	-1.2065	-1.6641	-1.1395	-1.5053	-1.0816	-1.3971	-1.0304	-1.3490	-0.9846	-1.3545
-1.2065	-1.9245	-1.1273	-1.7807	-1.0603	-1.6245	-1.0024	-1.5209	-0.9512	-1.4603	-0.9055	-1.3982
-1.0816	-2.1192	-1.0024	-1.9363	-0.9355	-1.7881	-0.8775	-1.6686	-0.8262	-1.6293	-0.7804	-1.6501
-0.9846	-2.2601	-0.9055	-2.1152	-0.8386	-1.9893	-0.7804	-1.9119	-0.7293	-1.9289	-0.6836	-1.9594
-0.8598	-2.4631	-0.7804	-2.3049	-0.7135	-2.1725	-0.6556	-2.0848	-0.6045	-2.0699	-0.5586	-2.0711
-0.8085	-2.5029	-0.7293	-2.3370	-0.6623	-2.2012	-0.6045	-2.1087	-0.5533	-2.0785	-0.5075	-2.0669
-0.7314	-2.4740	-0.6523	-2.2961	-0.5854	-2.1549	-0.5274	-2.0548	-0.4763	-2.0026	-0.4305	-1.9741
-0.6688	-2.4869	-0.5897	-2.2986	-0.5227	-2.1519	-0.4647	-2.0495	-0.4136	-1.9904	-0.3678	-1.9532
-0.5597	-2.4444	-0.4805	-2.2465	-0.4136	-2.1010	-0.3556	-1.9960	-0.3045	-1.9235	-0.2587	-1.8871
-0.4713	-2.3871	-0.3921	-2.1981	-0.3252	-2.0522	-0.2672	-1.9536	-0.2160	-1.9020	-0.1703	-1.8887
-0.3792	-2.3534	-0.3001	-2.1624	-0.2331	-2.0327	-0.1751	-1.9582	-0.1240	-1.9311	-0.0783	-1.9409
-0.3165	-2.3635	-0.2373	-2.1870	-0.1704	-2.0680	-0.1124	-2.0018	-0.0612	-1.9804	-0.0155	-1.9935
-0.2796	-2.3694	-0.2004	-2.2014	-0.1335	-2.0888	-0.0755	-2.0274	-0.0244	-2.0093	0.0214	-2.0244
-0.2649	-2.3718	-0.1857	-2.2072	-0.1188	-2.0970	-0.0608	-2.0376	-0.0097	-2.0208	0.0361	-2.0367
-0.2465	-2.3748	-0.1673	-2.2144	-0.1004	-2.1074	-0.0424	-2.0505	0.0088	-2.0353	0.0545	-2.0522
-0.2132	-2.3801	-0.1340	-2.2274	-0.0671	-2.1261	-0.0091	-2.0736	0.0420	-2.0614	0.0878	-2.0800
-0.1910	-2.3837	-0.1118	-2.2361	-0.0449	-2.1386	0.0131	-2.0890	0.0642	-2.0788	0.1100	-2.0986
-0.1651	-2.3878	-0.0859	-2.2463	-0.0190	-2.1532	0.0390	-2.1070	0.0901	-2.0991	0.1359	-2.1204
-0.1429	-2.3914	-0.0638	-2.2550	0.0032	-2.1657	0.0612	-2.1225	0.1123	-2.1165	0.1581	-2.1389
-0.1207	-2.4066	-0.0415	-2.2723	0.0254	-2.1869	0.0834	-2.1459	0.1345	-2.1402	0.1803	-2.1624
-0.0873	-2.4374	-0.0081	-2.3046	0.0588	-2.2248	0.1168	-2.1866	0.1679	-2.1800	0.2137	-2.2013
-0.0687	-2.4546	0.0105	-2.3225	0.0774	-2.2459	0.1354	-2.2093	0.1865	-2.2021	0.2323	-2.2229
-0.0575	-2.4650	0.0217	-2.3333	0.0886	-2.2587	0.1466	-2.2230	0.1977	-2.2154	0.2435	-2.2359
-0.0461	-2.4755	0.0331	-2.3443	0.1000	-2.2716	0.1580	-2.2369	0.2091	-2.2290	0.2549	-2.2492
-0.0272	-2.4930	0.0520	-2.3625	0.1189	-2.2931	0.1769	-2.2599	0.2280	-2.2515	0.2738	-2.2712
-0.0083	-2.5141	0.0709	-2.3867	0.1378	-2.3190	0.1958	-2.2870	0.2469	-2.2803	0.2927	-2.3027
0.0907	-2.6383	0.1698	-2.5363	0.2368	-2.4711	0.2948	-2.4432	0.3459	-2.4534	0.3917	-2.5034
0.0945	-2.6431	0.1738	-2.5422	0.2405	-2.4768	0.2986	-2.4493	0.3499	-2.4603	0.3955	-2.5113
0.1915	-2.8281	0.2707	-2.7254	0.3377	-2.6818	0.3955	-2.6859	0.4467	-2.7347	0.4925	-2.8093
0.3541	-3.1463	0.4334	-3.1134	0.5004	-3.1043	0.5583	-3.0633	0.6095	-3.0197	0.6552	-2.9703
0.4925	-3.5493	0.5717	-3.4470	0.6386	-3.3511	0.6966	-3.2464	0.7477	-3.1553	0.7935	-3.0846
0.7935	-4.1744	0.8727	-4.0370	0.9396	-3.9704	0.9976	-3.9531	1.0488	-3.9330	1.0945	-3.8875

**Notes.** <sup>(a)</sup> Photon energies  $\epsilon$  are in eV. <sup>(b)</sup> Photon densities  $\epsilon \frac{dn_\gamma}{d\epsilon}$  are in  $[\text{cm}^{-3}]$ .

**Table 2.** Photon proper number density as a function of redshift (2).

$z = 1.2$		$z = 1.4$		$z = 1.6$		$z = 1.8$		$z = 2.0$	
$\log \epsilon^a$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})^b$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$
-2.5410	2.7372	-2.5032	2.8128	-2.4684	2.8823	-2.4362	2.9467	-2.4063	3.0066
-2.4910	2.5912	-2.4532	2.6668	-2.4184	2.7363	-2.3862	2.8007	-2.3563	2.8606
-2.4410	2.4102	-2.4032	2.4858	-2.3684	2.5553	-2.3362	2.6197	-2.3063	2.6796
-2.3910	2.1882	-2.3532	2.2638	-2.3184	2.3333	-2.2862	2.3977	-2.2563	2.4576
-2.3410	1.9212	-2.3032	1.9968	-2.2684	2.0663	-2.2362	2.1307	-2.2063	2.1906
-2.2910	1.6032	-2.2532	1.6788	-2.2184	1.7483	-2.1862	1.8127	-2.1563	1.8726
-2.2410	1.2282	-2.2032	1.3038	-2.1684	1.3733	-2.1362	1.4377	-2.1063	1.4976
-2.1910	0.8942	-2.1532	0.9615	-2.1184	1.0215	-2.0862	1.0765	-2.0563	1.1277
-2.1071	0.4363	-2.0693	0.4732	-2.0346	0.5020	-2.0024	0.5253	-1.9722	0.5449
-1.9610	0.3406	-1.9234	0.3432	-1.8884	0.3310	-1.8564	0.3085	-1.8262	0.2765
-1.7934	0.2180	-1.7557	0.1770	-1.7210	0.1248	-1.6887	0.0607	-1.6588	-0.0101
-1.7091	0.0667	-1.6714	0.0022	-1.6366	-0.0682	-1.6045	-0.1385	-1.5745	-0.2066
-1.6045	-0.1226	-1.5667	-0.1886	-1.5319	-0.2548	-1.4998	-0.3188	-1.4697	-0.3806
-1.5173	-0.3989	-1.4795	-0.4578	-1.4448	-0.5186	-1.4125	-0.5822	-1.3826	-0.6505
-1.4381	-0.5950	-1.4003	-0.6552	-1.3655	-0.7196	-1.3334	-0.7844	-1.3034	-0.8508
-1.4082	-0.6411	-1.3704	-0.6938	-1.3356	-0.7486	-1.3034	-0.8022	-1.2734	-0.8542
-1.3412	-0.7916	-1.3034	-0.8468	-1.2687	-0.9020	-1.2364	-0.9582	-1.2065	-1.0175
-1.1651	-1.1519	-1.1273	-1.1756	-1.0925	-1.1974	-1.0604	-1.2007	-1.0304	-1.2146
-1.0401	-1.3461	-1.0024	-1.3801	-0.9678	-1.4397	-0.9355	-1.4734	-0.9055	-1.4750
-0.9431	-1.3512	-0.9055	-1.3205	-0.8706	-1.2847	-0.8386	-1.2890	-0.8085	-1.3492
-0.8642	-1.3601	-0.8262	-1.3685	-0.7916	-1.4405	-0.7595	-1.5277	-0.7293	-1.6434
-0.7392	-1.7245	-0.7014	-1.8256	-0.6666	-1.8941	-0.6343	-1.9473	-0.6045	-1.9759
-0.6423	-1.9743	-0.6045	-2.0022	-0.5698	-1.9991	-0.5375	-1.9931	-0.5075	-1.9927
-0.5173	-2.0707	-0.4795	-2.0853	-0.4448	-2.0808	-0.4125	-2.0746	-0.3826	-2.0848
-0.4661	-2.0603	-0.4283	-2.0697	-0.3936	-2.0648	-0.3614	-2.0586	-0.3314	-2.0729
-0.3891	-1.9598	-0.3513	-1.9629	-0.3166	-1.9573	-0.2844	-1.9511	-0.2545	-1.9703
-0.3265	-1.9303	-0.2887	-1.9249	-0.2539	-1.9301	-0.2217	-1.9431	-0.1918	-1.9741
-0.2173	-1.8858	-0.1796	-1.9066	-0.1448	-1.9378	-0.1126	-1.9751	-0.0826	-2.0270
-0.1289	-1.9105	-0.0911	-1.9476	-0.0563	-1.9831	-0.0242	-2.0182	0.0058	-2.0653
-0.0369	-1.9652	0.0009	-1.9950	0.0357	-2.0279	0.0679	-2.0676	0.0978	-2.1198
0.0259	-2.0171	0.0637	-2.0428	0.0984	-2.0725	0.1306	-2.1095	0.1606	-2.1579
0.0628	-2.0475	0.1006	-2.0708	0.1353	-2.0987	0.1675	-2.1341	0.1975	-2.1803
0.0775	-2.0597	0.1152	-2.0820	0.1500	-2.1092	0.1822	-2.1439	0.2122	-2.1893
0.0959	-2.0749	0.1337	-2.0960	0.1684	-2.1223	0.2006	-2.1562	0.2306	-2.2005
0.1292	-2.1024	0.1670	-2.1214	0.2017	-2.1460	0.2339	-2.1784	0.2639	-2.2207
0.1514	-2.1207	0.1891	-2.1383	0.2239	-2.1618	0.2561	-2.1932	0.2861	-2.2342
0.1773	-2.1421	0.2151	-2.1580	0.2498	-2.1802	0.2820	-2.2105	0.3120	-2.2500
0.1995	-2.1604	0.2372	-2.1749	0.2720	-2.1960	0.3042	-2.2253	0.3342	-2.2635
0.2217	-2.1840	0.2595	-2.1992	0.2942	-2.2221	0.3264	-2.2540	0.3564	-2.2967
0.2551	-2.2231	0.2929	-2.2410	0.3276	-2.2686	0.3598	-2.3071	0.3898	-2.3606
0.2737	-2.2448	0.3115	-2.2643	0.3462	-2.2944	0.3784	-2.3367	0.4084	-2.3962
0.2849	-2.2580	0.3227	-2.2783	0.3574	-2.3100	0.3896	-2.3545	0.4196	-2.4176
0.2963	-2.2713	0.3341	-2.2926	0.3688	-2.3258	0.4010	-2.3726	0.4310	-2.4394
0.3152	-2.2934	0.3529	-2.3162	0.3877	-2.3521	0.4199	-2.4026	0.4499	-2.4756
0.3341	-2.3283	0.3719	-2.3555	0.4066	-2.3939	0.4388	-2.4430	0.4688	-2.5130
0.4330	-2.5581	0.4708	-2.6189	0.5056	-2.6692	0.5378	-2.6935	0.5677	-2.7131
0.4370	-2.5672	0.4748	-2.6295	0.5095	-2.6800	0.5417	-2.7035	0.5717	-2.7212
0.5339	-2.8253	0.5717	-2.8160	0.6064	-2.8078	0.6386	-2.8014	0.6686	-2.7995
0.6966	-2.9057	0.7344	-2.8455	0.7692	-2.7974	0.8013	-2.7638	0.8313	-2.7480
0.8349	-3.0277	0.8727	-2.9888	0.9075	-2.9690	0.9396	-2.9771	0.9696	-3.0217
1.1358	-3.7761	1.1738	-3.6652	1.2084	-3.5770	1.2405	-3.5305	1.2707	-3.5042

**Notes.** <sup>(a)</sup> Photon energies  $\epsilon$  are in eV. <sup>(b)</sup> Photon densities  $\epsilon \frac{dn_\gamma}{d\epsilon}$  are in  $[\text{cm}^{-3}]$ .

**Table 3.** Photon proper number density as a function of redshift (3).

$z = 2.3$		$z = 2.6$		$z = 2.9$		$z = 3.2$		$z = 3.5$	
$\log \epsilon^a$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})^b$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$	$\log \epsilon$	$\log(\epsilon \frac{dn_\gamma}{d\epsilon})$
-2.365	3.089	-2.3271	3.1650	-2.2923	3.2345	-2.2602	3.2989	-2.2302	3.3588
-2.315	2.943	-2.2771	3.0190	-2.2423	3.0885	-2.2102	3.1529	-2.1802	3.2128
-2.265	2.762	-2.2271	2.8380	-2.1923	2.9075	-2.1602	2.9719	-2.1302	3.0318
-2.215	2.540	-2.1771	2.6160	-2.1423	2.6855	-2.1102	2.7499	-2.0802	2.8098
-2.165	2.273	-2.1271	2.3490	-2.0923	2.4185	-2.0602	2.4829	-2.0302	2.5428
-2.115	1.955	-2.0771	2.0310	-2.0423	2.1005	-2.0102	2.1649	-1.9802	2.2248
-2.065	1.580	-2.0271	1.6560	-1.9923	1.7255	-1.9602	1.7899	-1.9302	1.8498
-2.015	1.199	-1.9771	1.2640	-1.9423	1.3252	-1.9102	1.3519	-1.8802	1.4118
-1.931	0.5723	-1.8931	0.5938	-1.8586	0.6171	-1.8602	0.9315	-1.8302	0.9724
-1.785	0.2097	-1.7471	0.1323	-1.7124	0.0481	-1.6801	-0.0512	-1.6501	-0.1655
-1.617	-0.1159	-1.5795	-0.2188	-1.5449	-0.3124	-1.5127	-0.4018	-1.4827	-0.4929
-1.533	-0.3050	-1.4953	-0.3991	-1.4605	-0.4877	-1.4283	-0.5832	-1.3984	-0.6975
-1.428	-0.4735	-1.3905	-0.5737	-1.3558	-0.6790	-1.3236	-0.7865	-1.2936	-0.9010
-1.341	-0.7570	-1.3034	-0.8620	-1.2687	-0.9610	-1.2365	-1.0610	-1.2065	-1.1698
-1.262	-0.9527	-1.2242	-1.0576	-1.1895	-1.1603	-1.1573	-1.2683	-1.1273	-1.3898
-1.232	-0.9314	-1.1943	-0.9965	-1.1595	-1.0390	-1.1273	-1.0687	-1.0973	-1.0858
-1.165	-1.106	-1.1273	-1.1875	-1.0925	-1.2551	-1.0604	-1.3088	-1.0304	-1.3549
-0.9888	-1.260	-0.9512	-1.2984	-0.9165	-1.2831	-0.8844	-1.2378	-0.8545	-1.2016
-0.8642	-1.470	-0.8262	-1.5370	-0.7916	-1.6996	-0.7595	-1.9539	-0.7293	-2.2334
-0.7672	-1.511	-0.7293	-1.6757	-0.6946	-1.8245	-0.6625	-1.9662	-0.6325	-2.0691
-0.6880	-1.797	-0.6501	-1.9234	-0.6155	-2.0070	-0.5832	-2.0617	-0.5533	-2.1162
-0.5630	-2.004	-0.5252	-2.0324	-0.4905	-2.0593	-0.4583	-2.0876	-0.4283	-2.1206
-0.4661	-2.002	-0.4283	-2.0170	-0.3936	-2.0330	-0.3614	-2.0524	-0.3314	-2.0771
-0.3412	-2.121	-0.3034	-2.1647	-0.2687	-2.2197	-0.2365	-2.2707	-0.2065	-2.3264
-0.2900	-2.119	-0.2523	-2.1763	-0.2175	-2.2504	-0.1853	-2.3191	-0.1553	-2.3943
-0.2130	-2.030	-0.1752	-2.1046	-0.1405	-2.2072	-0.1083	-2.3051	-0.0784	-2.4165
-0.1503	-2.050	-0.1126	-2.1460	-0.0778	-2.2609	-0.0457	-2.3652	-0.0157	-2.4806
-0.0413	-2.117	-0.0035	-2.2074	0.0313	-2.3161	0.0635	-2.4317	0.0934	-2.5730
0.0472	-2.152	0.0850	-2.2468	0.1197	-2.3611	0.1519	-2.4871	0.1819	-2.6348
0.1392	-2.210	0.1770	-2.3025	0.2118	-2.4050	0.2440	-2.5218	0.2739	-2.6626
0.2011	-2.243	0.2398	-2.3364	0.2745	-2.4489	0.3067	-2.5842	0.3367	-2.7377
0.2388	-2.263	0.2766	-2.3563	0.3114	-2.4748	0.3436	-2.6208	0.3736	-2.7819
0.2535	-2.271	0.2913	-2.3642	0.3261	-2.4851	0.3583	-2.6354	0.3882	-2.7995
0.2711	-2.280	0.3098	-2.3742	0.3445	-2.4979	0.3767	-2.6537	0.4067	-2.8215
0.3052	-2.298	0.3430	-2.3921	0.3778	-2.5212	0.4100	-2.6868	0.4400	-2.8614
0.3274	-2.310	0.3652	-2.4041	0.4000	-2.5368	0.4322	-2.7089	0.4622	-2.8879
0.3533	-2.323	0.3911	-2.4181	0.4259	-2.5549	0.4581	-2.7346	0.4881	-2.9189
0.3755	-2.335	0.4133	-2.4301	0.4481	-2.5704	0.4803	-2.7567	0.5102	-2.9455
0.3977	-2.377	0.4355	-2.4706	0.4703	-2.6047	0.5025	-2.7811	0.5325	-2.9612
0.4311	-2.458	0.4690	-2.5518	0.5037	-2.6693	0.5359	-2.8194	0.5659	-2.9772
0.4497	-2.502	0.4875	-2.5969	0.5223	-2.7053	0.5545	-2.8407	0.5845	-2.9861
0.4609	-2.529	0.4988	-2.6242	0.5335	-2.7269	0.5657	-2.8536	0.5957	-2.9915
0.4723	-2.557	0.5101	-2.6519	0.5449	-2.7490	0.5771	-2.8666	0.6071	-2.9970
0.4912	-2.602	0.5290	-2.6978	0.5638	-2.7855	0.5960	-2.8883	0.6259	-3.0060
0.5101	-2.635	0.5480	-2.7254	0.5827	-2.8066	0.6149	-2.8999	0.6449	-3.0093
0.6091	-2.752	0.6469	-2.8009	0.6817	-2.8586	0.7139	-2.9239	0.7438	-3.0051
0.6130	-2.757	0.6508	-2.8039	0.6856	-2.8607	0.7178	-2.9249	0.7477	-3.0049
0.7099	-2.804	0.7477	-2.8235	0.7825	-2.8620	0.8147	-2.9216	0.8447	-3.0039
0.8727	-2.753	0.9105	-2.7793	0.9452	-2.8259	0.9774	-2.8880	1.0073	-2.9469
1.011	-3.155	1.0488	-3.3823	1.0835	-3.8026	1.1156	-4.6210	1.1455	-5.6309
1.312	-3.496	1.3499	-3.6416	1.3845	-4.1594	1.4168	-5.1688	1.4467	-6.4232

**Notes.** <sup>(a)</sup> Photon energies  $\epsilon$  are in eV. <sup>(b)</sup> Photon densities  $\epsilon \frac{dn_\gamma}{d\epsilon}$  are in  $[\text{cm}^{-3}]$ .

**Table 4.** Photon–photon optical depth as a function of energy and redshift.

Energy [TeV]	$\tau(z, E_\gamma)$ $z = 0.01$	$\tau(z, E_\gamma)$ $z = 0.03$	$\tau(z, E_\gamma)$ $z = 0.1$	$\tau(z, E_\gamma)$ $z = 0.3$	$\tau(z, E_\gamma)$ $z = 0.5$	$\tau(z, E_\gamma)$ $z = 1.0$	$\tau(z, E_\gamma)$ $z = 1.5$	$\tau(z, E_\gamma)$ $z = 2.0$	$\tau(z, E_\gamma)$ $z = 2.5$	$\tau(z, E_\gamma)$ $z = 3.0$
0.00520	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00098	0.00250
0.00631	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00041	0.00384	0.00706
0.00767	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00238	0.01031	0.01614
0.00932	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00052	0.00770	0.02253	0.03325
0.01132	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00269	0.01862	0.04384	0.06308
0.01375	0.00000	0.00000	0.00000	0.00000	0.00000	0.00020	0.00834	0.03824	0.07863	0.10985
0.01671	0.00000	0.00000	0.00000	0.00000	0.00000	0.00144	0.02010	0.07046	0.13069	0.17634
0.02030	0.00000	0.00000	0.00000	0.00000	0.00000	0.00526	0.04148	0.11902	0.20242	0.26437
0.02466	0.00000	0.00000	0.00000	0.00000	0.00026	0.01411	0.07640	0.18647	0.29553	0.37522
0.02997	0.00000	0.00000	0.00000	0.00006	0.00168	0.03132	0.12823	0.27492	0.41267	0.51353
0.03641	0.00000	0.00000	0.00000	0.00075	0.00574	0.06037	0.19977	0.38853	0.56127	0.68797
0.04423	0.00000	0.00001	0.00013	0.00320	0.01442	0.10498	0.29586	0.53788	0.75593	0.91357
0.05374	0.00004	0.00015	0.00090	0.00881	0.03012	0.17000	0.42821	0.74227	1.01767	1.21240
0.06529	0.00017	0.00059	0.00279	0.01897	0.05553	0.26482	0.61799	1.02783	1.37303	1.60979
0.07932	0.00044	0.00146	0.00625	0.03557	0.09497	0.40704	0.89424	1.42494	1.85166	2.13489
0.09636	0.00090	0.00292	0.01196	0.06187	0.15657	0.62209	1.28834	1.96569	2.48455	2.81862
0.11708	0.00164	0.00530	0.02132	0.10376	0.25361	0.93967	1.83323	2.68098	3.30228	3.69168
0.14224	0.00288	0.00923	0.03649	0.17004	0.40341	1.38927	2.56014	3.59959	4.33198	4.78158
0.17281	0.00485	0.01543	0.06030	0.27160	0.62492	1.99735	3.49334	4.74466	5.59439	6.10519
0.20995	0.00785	0.02488	0.09631	0.42039	0.93622	2.78417	4.65017	6.12472	7.09190	7.66666
0.25507	0.01228	0.03875	0.14856	0.62743	1.35031	3.75962	6.02682	7.72167	8.80131	9.44462
0.30989	0.01849	0.05813	0.22045	0.89889	1.87116	4.91140	7.58655	9.48565	10.6756	11.3903
0.37650	0.02671	0.08371	0.31387	1.23409	2.49233	6.20194	9.26186	11.3434	12.6433	13.4434
0.45742	0.03695	0.11541	0.42716	1.62395	3.19434	7.56774	10.9660	13.2189	14.6472	15.5431
0.55573	0.04889	0.15213	0.55633	2.05458	3.94206	8.93147	12.6258	15.0605	16.6643	17.7073
0.67516	0.06195	0.19214	0.69563	2.50232	4.69382	10.2273	14.2003	16.9030	18.7701	20.0347
0.82027	0.07565	0.23399	0.83870	2.94180	5.40766	11.4154	15.7408	18.8822	21.1241	22.7128
0.99657	0.08899	0.27442	0.97492	3.34713	6.05113	12.5223	17.3990	21.1526	23.9144	25.9438
1.21076	0.10138	0.31194	1.09952	3.70442	6.61381	13.6400	19.3428	23.8785	27.3181	29.8841
1.47098	0.11221	0.34440	1.20615	4.00661	7.11168	14.9226	21.7192	27.2691	31.5636	34.8158
1.78712	0.12140	0.37194	1.29529	4.26781	7.60245	16.5345	24.7027	31.5446	37.0071	41.2633
2.17122	0.12901	0.39470	1.37052	4.52208	8.16693	18.5987	28.5221	37.1930	44.2853	50.0201
2.63787	0.13601	0.41568	1.44294	4.82080	8.91296	21.2999	33.6172	44.8184	54.3879	62.3975
3.20481	0.14377	0.43949	1.53147	5.22872	9.95027	24.9165	40.6821	55.7377	69.2046	80.6985
3.89360	0.15419	0.47162	1.65382	5.81803	11.3558	29.9010	50.8562	71.9941	91.3676	108.244
4.73042	0.16911	0.51756	1.83234	6.62927	13.2598	37.1520	66.2602	96.9755	125.369	150.666
5.74710	0.19065	0.58408	2.08465	7.71468	15.8888	47.9635	90.2827	135.775	177.700	218.111
6.98230	0.21876	0.67023	2.41055	9.20728	19.6965	64.8492	128.281	195.456	257.948	338.714
8.48296	0.25607	0.78567	2.85808	11.3604	25.5316	92.0801	187.290	285.133	384.066	621.861
10.3061	0.30752	0.94942	3.50961	14.7030	34.7408	135.263	275.826	415.094	615.195	1451.43
12.5211	0.38586	1.19616	4.50601	20.0272	49.6450	200.724	399.269	608.090	1175.933	3855.73
15.2122	0.51166	1.59762	6.14335	28.6023	73.4936	293.144	563.797	952.984	2741.434	9943.42
18.4817	0.71277	2.23537	8.72773	42.3560	109.697	414.810	786.935	1776.48	6841.312	–
22.4539	1.03624	3.25844	12.9010	63.5006	160.938	565.925	1156.41	3963.61	–	–
27.2798	1.55756	4.90160	19.4448	93.6672	227.793	749.334	2000.75	9319.26	–	–
33.1429	2.33730	7.33367	28.8458	133.104	308.522	1013.70	4181.95	–	–	–
40.2661	3.40014	10.6261	41.1443	180.335	400.080	1548.18	9404.14	–	–	–
48.9203	4.72388	14.6948	55.8835	233.223	505.738	2907.47	–	–	–	–
59.4344	6.23960	19.3110	72.1970	290.373	660.765	6283.00	–	–	–	–
72.2083	7.82189	24.1678	89.2541	364.018	1014.58	–	–	–	–	–
87.7276	9.50683	29.3591	109.080	522.730	1997.66	–	–	–	–	–
106.582	11.8962	37.2086	147.522	996.470	4510.25	–	–	–	–	–
129.489	18.3001	59.3783	268.848	2318.77	9990.42	–	–	–	–	–
157.319	39.6796	132.463	642.223	5410.71	–	–	–	–	–	–
191.131	99.7780	333.153	1579.26	–	–	–	–	–	–	–
232.210	235.983	777.945	3498.49	–	–	–	–	–	–	–

**Notes.** The absorption multiplicative factor is  $e^{-\tau(z, E_\gamma)}$ .