

# CATALOG OF EMISSION NEBULAE

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This catalog is a revised summary of four previously published lists of nebulae, with some additions. In table. 1, in addition to the coordinates, are given: angular size, brightness, classification and old designations of nebulae (columns 6, 7, 8, 9): This list is less detailed than the previous (separate nearby nebulae or parts are often grouped here under one number). Notes are given separately at the end of table 1. Exciting stars are listed in table 2, links to photographs for different nebulae in table 3.

In recent years, the Crimean Astrophysical Observatory has published four lists of emission nebulae [1, 2]. Results of Observations Started at Simeis in 1949, published as observations accumulated, obtained on two fast cameras 450 and 640 mm. (F/1.4). Satisfactory field is small, about 3° in diameter. For these cameras, the scale is respectively 5.7' and 4.0' (in mm.). The images were taken on Eastman Kodak 103aE plates in combination with a KC5 red filter (transmission region approximately  $\lambda$  6330 -  $\lambda$  6600).

At the present time there is a need to give one summary list of nebulae, making it more convenient to use. In addition, this consolidated revised list contains a lot of new information.

In previous lists, we often over-detailed the designations of the nebulae. Now it seems more appropriate to give fewer numbers, bringing together, when possible, a few parts or nebulae. However, there may be different opinions on how far one can go in this regard.

Besides, the difficulty in cataloging nebulae is partly due to the presence of a noticeable emission background almost everywhere in very low galactic latitudes. This is clearly seen in the photographs of the Atlas of the observatory [3]. In particular, an almost solid background is revealed in Cygnus from 19<sup>h</sup>35<sup>m</sup> to 20<sup>h</sup>45<sup>m</sup> in  $\alpha$  and from 32 to 48° in  $\delta$ , as well as in Cepheus from 22<sup>h</sup>0<sup>m</sup> to 23<sup>h</sup>15<sup>m</sup> in  $\alpha$  and from +58 to 63° in  $\delta$ . In earlier listings, some of the more visible features of this emission background were labeled as individual nebulae, but in the present summary list some of them are either omitted or entered as a field in the nearest, brighter individual nebulae. The list does is not claimed to be complete. The accessible part of the galactic belt was considered for the most part within  $\pm 10^\circ$  in latitude. But this limit is far from being maintained, especially in winter hours. At 16h and 17h only a small number of pictures were taken. Due to the small scale, it was almost impossible to detect nebulae smaller than 0.5'-1.0'. The overwhelming majority of the pictures were taken only in red light. Partly in connection with the latter, a small number of nebulae may turn out to be reflective. Some nebulae in table 1 are marked as reflective or partially emissive. The plates used for the work have aged over time, and obtaining very faint nebulae became impossible.

The list of nebulae is presented in table 1 (page 16). This includes the nebulae from our four lists above, several new nebulae and a number of mostly very faint or small nebulae, which we found after the appearance of the recent Mount Wilson catalog [4]. This catalog was received in early 1954, when our small fourth list was practically out for print [2].

The first column of table 1 shows the current number in our consolidated list. The asterisk indicates a note at the end of table 1.

Columns 2 and 3 give  $\alpha$  and  $\delta$  for 1900, and in 4 and 5, respectively, the galactic latitude and longitude. In rare cases, the coordinates are given arbitrarily for the brighter part of the nebula. Position accuracy is about 1', sometimes the accuracy is less.

Column 6 lists the angular dimensions (approximately in two perpendicular directions to characterize the elongation of the nebula). The size is mostly determined inaccurately. If there is another field in addition to the nebula itself, or there is only one field, then the size is enclosed in square brackets.

Brightness. The brightness is given in the 7th column. For 20 nebulae, the brightness from one square minute of arc was determined by referencing out-of-focus images to the NPS polar sequence (red magnitude system). Our red values of m depend on the instrumental characteristics (in particular, on the spectral sensitivity of the plates and on the part of the spectrum that is passed through by the KC5 filter). The accuracy here is probably  $\pm 0.20^m$ . For these

nebulae, we had the opportunity to free  $m_r$  from the influence of a continuous spectrum and obtain the corresponding value of  $m_{H\alpha}$  [5].

Since the photographs were generally taken with a single exposure, by comparing all other nebulae with our "standard" nebulae, we could get a rough eye-estimate of the brightness. The accuracy here, of course, is very low, but the error hardly exceeds  $0.5^m$ . However, we do not give values, but figures indicating the probable limits: 1 - brighter than  $9.5^m$ ; 2 - between  $9.4^m$  and  $10.1^m$ ; 3 - between  $10.0^m$  and  $10.7^m$ ; 4 - between  $10.6^m$  and  $11.3^m$ ; 5 - between  $11.2^m$  and  $11.9^m$ ; 6 - between  $11.8^m$  and  $12.5^m$ ; 7 - between  $12.4^m$  and  $13.1^m$ ; 8 - fainter than  $13.0^m$ .

Classification. In column 8, Roman numerals and letters characterize the classification of nebulae and other features. Diffuse nebulae are so diverse in their structure that it is difficult to speak of any kind of classification. However, nebulae exhibit some common characteristics, such as: the presence of filaments, the inclusion of dark matter, elongation, structure or amorphism, etc. Instead of long descriptions, it is better to give symbols, especially since some of them probably have a physical meaning. Unfortunately, due to the great diversity, we could not limit ourselves to a shorter classification. We have developed the following designations:

- I. Irregular, diffuse.
- II. Structured with individual parts.
- III. Nebulae with a known concentration of matter along the periphery in the form of a complete ring or part of it (peripheral).
- IV. Filamentary: a - entirely filamentary, b - partially filamentary, c - including individual filaments.
- V. More regular spherical ones (more uniform in brightness or with a known gain towards the center).
- VI. Very elongated nebulae.
- VII. Nebulous stars or small nebulae  $\sim 1''$ .
- VIII. Large fields of more or less uniform brightness.

*\* For these nebulae, a brightness of 7 is indicated for the center.*

To indicate the inclusion of dark matter (nebulae, globules, dark filaments) the letter d is added to the classification. It seems difficult to indicate the relation of this conditional classification to other proposed classifications (although they have common ground).

Designations. The last column gives the designations of the nebulae: NGC, IC, our old numbers with the letter S (Simeis) in front [1, 2], W [4], Mi I and Mi II [6], H [7, 8], McD [9], Ced [10], St [11]. A few remarks need to be made regarding our older notation. For example, according to IC, there is a round nebula and a cluster. But IC 1805 surrounded by a very large ellipse, and this part was designated as S3. In addition, in the vicinity there are several separate parts that have received separate designations. Another example is NGC 6604 (according to the description, NGC is a cluster, not a nebula). As for the nebula here, we have noted three formations of various kinds: Mi I<sub>8</sub>, S190 and S191 (№ 141 table 1). Sharpless gives only one number 41 and indicates an identification with NGC 6604.

In our previous lists, several old S numbers around  $18^h - 24^\circ$  turned out to be fields of stars, S31, S121 are non-existent. A few small nebulae may be reflective or partially reflective. Several of the announced numbers we could later identify with other sources.

Exciting stars. Exciting stars can be classified in cases where the stars O, B0, B1 are more or less in the central region. In other cases, we face difficulties. Very often the stars O, B0, B1 are far from the center, on the edge of the nebula or even outside it, although close. The probability that there is only a random angular proximity on the image plane is small, and therefore, in this case, the vast majority of these stars are also exciting. It is quite difficult to solve the problem of exciting stars when the angular distance reaches  $1^\circ$  or more. At a distance of 1000 ps,  $1^\circ$  corresponds to 18 ps, and the nebula will still for the most part be in the sphere of ionization of O, B0 stars. However, the effect of random proximity already plays a significant role, and in this case exciting stars are indicated when there are grounds to believe that the star and the nebula are relatively close to us. Table 2 (p. 26) gives a list of nebulae for which exciting stars could be more or less confidently indicated. More questionable cases are marked with a colon. Only stars of class W, O, B0, B1 and, in very rare cases, B2 are indicated. For these stars, the classification is taken from various sources (mainly Mount Wilson, Yerkes-MacDonald, Lick, Victoria). Of the objective prism class definitions, HD and HDE have been used almost exclusively. If there are many exciting stars, then sometimes only some are given. As can be seen, only approximately 54% of nebulae could be marked with exciting stars. However, this does not mean that the remaining nebulae (46%) do not have exciting stars. Firstly, we did not consider the B2-

B5 stars, which could mistakenly be classified as too old. But it is even more probable that for many nebulae the exciting stars are fainter than 9.5, and few such B0 stars have been classified. If the nebula is located at a distance of 1500 is and the interstellar absorption is  $3^m$ , then the exciting star at 0 will be fainter than 9.5. Finally, in a considerable number of cases where the distance is less than 1 kpc, even at an angular distance of  $1.5^\circ$  the nebula will be in the sphere of ionization of O, B0 stars.

Star numbers less than 200,000 are HD, and more than 200,000 are HDE. Sources other than BD are: RVC [12], J-M [13], M [14], Hubble [15].

Images. In order to facilitate location of nebulae, we include table. 3, page 29, containing links to various images. However, references could only be given for 154 numbers in table 1.

The symbols of the sources are the following:

1. A: Atlas of diffuse gaseous nebulae [3].
2. VI, VII, IX, X, XI: News publications of the Crimean Astrophysical Observatory with indication of figure number [1, 2].
3. AJ: Astronomical Journal.
4. FR: Atlas of gas and dust Nebulae [16].

In addition, 8 sheets with images of nebulae are attached to this catalog, mainly for areas where nebulae are more crowded, such as in Cygnus. In table 3, they have designations, for example, f5-b, i.e. Fig. 5b.

A summary of all lists of nebulae into one general catalog was made after the death of V.F. Gaze. The work was carried out with the very active participation of E. I. Iosko and L. P. Metik.

1 March 1955.

## Literature

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13. H. Johnson, W. Morgan. Ap. J. 119, 349, 1954.
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15. P. Hubble. Ap. J. 56, 162, 1922.
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2. Arc.
9. IC59, IC63 fan-shaped. Parts of S111, S112; field to NE of  $\gamma$  Cassiopeia.
12. Multi-filamentary sickle.
13. Possibly reflective.
14. To SW of IC1795.
15. Coordinates conditionally for IC1795. Adjacent S1, S2.
16. IC1805 is a cluster and circular nebula surrounded by the large ellipse S3. Field with many parts S115, S26 etc.
18. Two long jets to the NE of S3.
23. Sickle to SW of IC1848.
26. Bright, adjacent to IC1848 from the east.
29. A field with more prominent parts S147 and S118.
32. Bright core surrounded by a diffuse nebula.
36. Diffuse S25 with bright part NGC1491.
38. Bright core surrounded by a faint diffuse nebula.
40. S119 = IC359? (distance 6'). Possibly reflective.
- 45, 46. Possibly related.
53. The specified parts SW of IC405 are probably related to the latter.
54. IC405. The part within is probably of a special nature.
55. Within IC410 are two cometary nebulae.
56. The western edge is sharply bounded (on the side of the dark nebula).
57. Field. includes № 58, 59, 60, 61, as well as S127, S128.
60. Also S135, S134.
61. Possibly an ellipse. The coordinates are conditionally for the brighter part.
64. Includes S153, S136, S137, S139, S140, S134, Barnard 122, S304, S154.
65. A field that includes NGC1976, NGC1977, NGC1982, S143, S144.
70. Probably partially emissive.
72. Field west of IC434, includes S141, S148.
74. The system of fine-filamentary, arcuate nebulae forms an almost closed circle of  $\sim 3^\circ$ . Includes S147, S149, S151, S155.
77. The most prominent part of the filamentary nebula system S147.
81. Probably partially emissive.
82. A parabola near FU Orionis. The former designation S280 is erroneous.
84. West of NGC2175 and likely associated with it.
86. S34 large diffuse surrounding McD43.
- 88, 89, 90, 91. Four nebulae belonging to the same group.
94. A system of curved filaments in the NE-SW direction outside and inside IC443 + S40. North of S41 there is a faint field of about  $60' \times 36'$ .
95. IC443 - bright arc to NE, S40 - more of a semicircle, closing IC443. Radio source. Possibly related to New 837.
97. The field surrounding NGC 2237. Includes distant parts S162, S157.
98. St27 - southern bright part, S158 - large diffuse to N, W, NE.
101. Three parallel bands.
102. A group of nebulae that also includes S167, S166, S161 and S164.
103. Extensive elongated SW-NE (parts S165, McD37, McD42, St121, St24).
108. Cometary, probably reflective.
109. In IC the position  $7^h 0.4^m - 10^\circ 33'$ , is probably incorrect (?). Probably identical to St18.
110. Sharp edge (W) bordering a dark nebula.
111. Possibly together with No. 114 and others nearby.
116. NGC2359 is transitional to planetary. In NGC, the position is incorrect by 1m. Bigurdan gives the correct position, but labeled it NGC2361. Includes IC468; S175,  $9' \times 7'$ , adjoins on the east.
118. Filaments at the western edge of the partial reflection nebula surrounding  $\sigma$  Scorpii.
119. A group of several bright nebulae. One of them is peripheral with an O star in the center (radio source).
122. Possibly reflective.
124. W21 is the southeastern part of S182.
125. To the north is a structured, reflective nebula near HD164 514 (cA8).
130. Four distinct nebulae stand out against the background of S188: IC1274 ( $18^h 4.0^m - 23^\circ 42'$ ,  $7' \times 7'$ ), IC1275 ( $18^h 4.4^m - 23^\circ 47'$ ,  $6' \times 8'$ ), IC4685 ( $18^h 3.6^m - 24^\circ 0'$ ,  $9' \times 5'$ ) and NGC6559 ( $18^h 4.2^m - 24^\circ 8'$ ,  $16' \times 13'$ ).

132. Possibly reflective.
- 139, 140. Possibly related.
141. Consists of three different formations: 1) small, bright Mil, 8, 6'×4', 2), bright wide semi-ellipse S191 (45'×30'), 3) pretty bright big S190 (80'×75'); NGC6604 only applies to clusters of stars with a center 18<sup>h</sup>12.5<sup>m</sup> - 12°17'.
142. S189 separate to NW of NGC6611.
144. IC4706 and IC4707 brighter knots in S193.
152. Wisps of nebulosity surrounding a group of stars.
160. Possibly partially emissive.
163. Possibly reflective.
165. Reflective.
166. NGC6820 a separate small nebula < 1' SW of the main bright large nebula S199 = W65, inside which is a distinct star cluster NGC6823 and a long dark filament; S200 is a faint nebula north of S199.
167. South of S43; W67 is only the brighter part of S201.
169. To the south of S44 is a small sharply outlined dark nebula.
170. Sickle shape.
177. Several identically oriented parts. To the south is an emission field.
179. Also includes S50, S51, McD12, S207, S209. A remarkable system of nebulae (partially filamentary) with, to some extent, a similar structure and orientation. There are dark filaments south of the center.
182. Between S49, McD11, McD10, S52a.
183. Very elongated nebula or a group of filamentary nebulae. The length is about 7.5°. This group probably includes many nebulae elongated more or less in the same NE direction. The total length is about 12°!
186. Nebula to the SW of IC1318a. Between IC1348a, S52, McD10, S58.
190. System of very thin long filaments in SW-NE direction crossing  $\alpha^2$  Cygni.
194. Near P Cygni with isolated clumps against a faint field background.
200. Very elongated. Probably refers to the system S107, S48 - S108.
201. Group surrounding  $\gamma$  Cygni: IC4318b, S60, S62, S64, S66, S68.
204. A faint nebula to the S of IC1318c, crossed by a dark nebula.
216. Loop shape.
217. It is possible that S216, S214 and others to the SW belong to system № 183.
221. Filamentary nebula system with southward extension (S230).
222. Also S231, S235 are arranged in an arc parallel to NGC6960.
223. Identically oriented nebulae IC5068, S81, S82, S83, S84.
224. A system of filamentary nebulae arranged in an arc parallel to the system NGC6960 and NGC6992. Includes anonymous (S229), S223, S225, S228, S232, S106, S238, S242.
225. Possible continuation of S216 and other elongated nebulae to the SW.
227. A group of nebulae located approximately in an arc parallel to the system NGC6960 - NGC6992 (NGC6978? S237, S233, S247, S246, S239, S241).
228. Approximately equally directed. Probably belong to the same system as № 221, 224, 227, 231.
233. Also S251, S253. The nebulae are scattered against a very faint background.
234. Part of S255- filaments NGC7000 to the NE. To the NW is a large very faint field 1,8°×1,5° (S244).
235. Peripheral. Apparently, the core is partially emissive, the ring is reflective.
236. East of NGC7000. S254 stands out more.
240. Peripheral S88 with parts S87, S89, S90, S91.
241. Possibly reflective.
243. To the SW and SE of 72 Cygni,  $\alpha$  and  $\delta$  conditionally for the brighter part of S299.
247. Faint field surrounding 19 Cephei.
248. Faint field near  $\gamma$  Cephei.
249. Two close bright filaments: S263 (12'×1') and S264 (6'×1').
250. Faint field. In the northern part there is a brighter nebula ~12' with a very bright arc bordering a dark nebula. The coordinates are conditional for the arc.
251. Almost McD19, S265 etc. Superimposed over an uneven field.
252. To the SE of  $\epsilon$  Cephei. Divided into three parts by dark lanes. To the SE and SW are arcs > 1°.
253. Bright arc 12'×3', Mill16 = S9 = S93 on the edge of fainter S94 = W92.
254. Half-ring.
255. Field on which elongated S268 and ragged S95 stand out.
256. A very faint nebulous star, possibly reflective.
257. Elongated nebula to the W and SW of 10 Lacertae.
258. Several elongated filaments to the NW of 10 Lacertae.

- 259. Field surrounding 10 Lacertae.
- 262. Faint, surrounds two faint stars, possibly reflective.
- 265. Two close ones W101 and W102. At a distance of 5' is W100.
- 272. Spiral structure.
- 273.  $\alpha$  and  $\delta$  conditionally for the brighter part of S100 superimposed over a faint nebula.
- 274. Also S12, S271. Surrounding the field W109.
- 277. Combination of nebulae: NGC7635 (transitional to planetary), individual diffuse parts S18, S17 and the surrounding field S19.
- 285. A group of nebulae that also includes Ced. 214 = S278, S274, S277, S109, S110, S275 and surroundings.