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C. LINE RADIATION FROM THE GALAXY

Ben Zuckerman

The goal of this section is to provide a complete bibliography of papers published in the past three years. A short list of various reviews and symposia is also included. The following discussion is an attempt to indicate what topic each reference is about. For a fuller discussion of the content of these papers, the reader is referred to the relevant reports to Commission 34 in the present volume and especially to the reviews listed below.

1. *21-Centimeter hydrogen line*

Hydrogen line absorption interferometry in the Northern (**165**) and Southern (**139, 270, 271, 272, 273**) hemispheres has yielded important new information relating to the two-component models of H I regions. Surveys of various regions with single antennas have also been carried out in the Northern (**7, 30, 31, 74, 75, 76, 217, 265, 279, 320, 321, 322, 325, 349, 368, 369, 374, 386, 393**) and Southern (**139, 154, 187, 188, 190, 271, 272, 273**) hemispheres. From these, various pictures of galactic structure (**32, 33, 34, 95, 167, 197, 227, 228, 289, 290, 291, 292**) are obtained. Specific sources have been examined (**18, 19, 45, 57, 92, 109, 110, 123, 124, 125, 138, 162, 166, 170, 184, 185, 193, 202, 232, 277, 302, 306, 347, 348, 371, 377, 379, 380, 391, 416**). The high velocity clouds (**62, 87, 168, 192, 195, 205, 206, 231, 242, 276, 372, 381, 384, 387, 388**) and high velocity gas near the galactic center (**203, 204, 234, 307, 308, 309**) have received special attention. 21-centimeter emission and/or absorption has been used to obtain pulsar distances (**86, 126, 127, 143, 144, 225, 304**) and to study cold clouds and the abundance ratio of dust and gas (**221, 268, 279, 293, 303, 305, 324, 339, 373, 385, 392**) and magnetic fields through the Zeeman effect (**24, 370, 375, 376, 382**). Papers have been written on determination of the astronomical unit (**244**), 21-cm optical depths (**107, 152**), the total mass of atomic hydrogen gas in the galaxy (**122**), and lunar occultation in the 21-cm line (**201**).

2. *Recombination lines*

The so-called 'diffuse' interstellar medium has recently been the object of considerable observational (**66, 131, 133, 140, 171**) and theoretical (**40, 130**) work. Hydrogen lines from discrete H II regions in the Northern (**51, 52, 54, 61, 77, 128, 129, 132, 135, 233, 235, 250, 251, 255, 256, 274, 280, 282, 294, 297, 298, 326, 337, 404, 405, 406**) and Southern (**35, 69, 99, 100, 237, 238, 240, 241, 407**) hemispheres have been investigated. Theoretical analysis of recombination lines from predominantly ionized (**4, 5, 20, 21, 22, 23, 83, 117, 156, 157, 158, 159, 160, 253, 263, 318**) and from predominantly

neutral (**81, 82, 93, 94, 111, 142, 264, 301**) gas have been carried out. Planetary nebulae have been investigated with recombination lines (**116, 161, 295, 341, 342**). Further helium abundances have been obtained (**16, 53, 239**). Carbon (**80, 239, 254, 423**), hydrogen (**9, 41, 43, 44, 49**) and other (**42, 46, 47**) recombination lines have been observed from H I regions. The galactic distribution of H II has been investigated (**6, 113, 114, 189**).

3. OH *lines*

There have been general studies of the OH lines in radio continuum sources (**56, 73, 78, 137, 226, 286, 287, 355, 357, 359, 360**), in optically dark clouds (**149, 150, 363, 367, 383**), from infrared sources and stars (**36, 37, 48, 96, 252, 281, 283, 285, 409, 410**), and from the galactic center (**183, 218, 219, 220, 288**). Specific objects have been examined in considerable detail (**65, 97, 136, 223, 224, 278, 284, 310, 396, 402, 412, 418**). Interferometry (**58, 64, 84, 145, 146, 147, 148, 273, 410, 411**) has been carried out on the OH maser sources. An OH occultation was observed (**60**) and the statistics of maser radiation studied (**90**). Searches for OH in various regions have been carried out (**191, 198, 413**). Radiation from excited rotational levels has been observed (**101, 103, 104, 249a, 299, 343, 365, 424, 426**) and searched for (**10, 12, 356**). ^{18}OH has been studied (**14, 98, 408**). Models for the maser radiation have been proposed (**2, 17, 91, 118, 119, 120, 172, 209, 210, 211, 212, 213, 214, 266**). Laboratory measurements of the OH frequencies have been made (**10, 55, 236**) as well as an astronomical estimate (**222**). An OH formation mechanism has been discussed (**182**).

4. H_2CO *lines*

Formaldehyde has been studied at 6-cm wavelength in the direction of continuum sources (**65, 108, 207, 315, 395, 401, 403, 420**), optically dark nebulae (**207, 327**), the galactic center region (**105, 106, 183, 310, 314, 316, 317, 394**) and elsewhere (**134**). Models have been proposed to explain the anomalous cooling of the 6-cm transition (**210, 248, 344, 350**). An H_2CO occultation was observed (**194**). The 2-mm lines from ortho and para-H_2CO (**208, 346**) and the 2-cm line (**88**) have been observed. The ^{13}C and ^{18}O isotopic forms have been studied (**102, 394**). Precise laboratory measurements of H_2CO transition frequencies have been carried out (**246, 352, 353, 354**) as well as studies of H_2CO photo dissociation rates (**112, 338**).

5. *Other molecules*

Observations have been made of CO (**257, 259, 260, 313, 332, 335, 397, 400**), CN (**174, 258, 400**), H_2O (**1, 13, 26, 28, 29, 71, 153, 180, 181, 200, 229, 312, 329, 340, 361, 366**), HCN (**243, 330, 399, 415, 421**), SiO (**70, 72, 398**), CH_3OH (**11, 15, 362, 399, 425**), HNCO (**331**), HC_3N (**358**), NH_2CHO (**141, 275, 296**), H_2CS (**63, 328**), H_2CO_2 (**38, 419**), NH_3 (**50, 199, 249, 422**), CS (**261, 400, 421**), CH_2NH (**115**), H_2S (**345**), CH_3CN (**333**), C_3H_4 (**331**), OCS (**176**), and at least two unidentified lines (**25, 27, 196, 331, 421**). A number of unsuccessful searches for other molecules have also been reported (**39, 68, 151, 164, 169, 175, 230, 364**), most notably searches for H_2^+ (**85, 173, 323**). Transition frequencies for CH (**8**), HC_3N (**67, 177**), HNCO (**163**), H_2CS (**178**), H_2^+ (**215, 336**), NO (**247**), CH_3OH (**269**), and HNO (**300**) have been measured in the laboratory.

6. *Miscellaneous*

Searches have been carried out for a hyperfine structure line from ^{3}He (**267, 319**) and a 3-cm fine structure line of H (**245**). Excitation of molecules has been investigated (**3, 59, 121**) and molecule formation and destruction processes have been considered (**79, 334, 338, 389, 390, 414**). A search for intelligent life by means of monochromatic 927 MHz emission was undertaken (**351**).

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D. EXTRAGALACTIC RADIO ASTRONOMY 1969–1972

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Radio astronomy shows increasing astrophysical diversity and the extragalactic branch ranges from spiral structure through relativistic astrophysics of nuclei of galaxies and quasars to observational cosmology. A bibliographic listing of about 700 papers under almost forty headings and subheadings has been prepared which systematically covers the subjects within our terms of reference. We list all relevant articles published in the journals listed in Section B(i), covering the period from July 1969 to November 1972. Comprehensive accounts of the subject may be found in the