40. RADIO ASTRONOMY (RADIO ASTRONOMIE)

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1. GENERAL REMARKS

Thousands of papers in the field of radio astronomy have appeared during the last three years. Even simple enumeration of the major achievements will take much more space than it has been allocated to Commission 40. Therefore, taking into account the tendency of the previous years, much greater attention in the present report has been paid to the actual material and references (mainly of observational and methodological character). As to the interpretation of observations, much overlapping has occurred with Commissions 10 and 34. Solar radio astronomy had to be excluded from the report of Commission 40 in view of its practically complete overlapping with the report of Commission 10. Physical interpretation of insterstellar medium observations carried out by radio techniques during the three years has been included in the report of Commission 34. Even in this case we have been forced, as in the previous years, to introduce some additional abbreviations of the most widely used journals in the sections containing a great number of references. These abbreviations are given below.

ABBREVIATIONS

AA = Astronomy and Astrophysics
Act Astr = Acta Astronomica
AJ = Astronomical Journal
AJP = Australian Journal of Physics
AN = Astronomische Nachrichten
AO = Astronomical Observatory
ApJ = Astrophysical Journal
AL = Astrophysical Letters
ASS = Astrophysics and Space Science
Astrofiz. = Astrofizika
ARAA = Annual Reviews of Astronomy and Astrophysics
AZh = Astronomicheskij Zhurnal
BAAS = Bulletin of the American Astronomical Society
CIAL = Coll. Int. Astrophys. Liège
CR = Comptes Rendus de l' Academie des Sciences, Paris
IEAM = First European Regional Meeting in Astronomy (Athens)
HA = Highlights of Astronomy
IAU Circ. = IAU Circular
IAU Symp. = IAU Symposium
IEEE = Transactions of the Institute of Electrical and Electronic Engineers
IzvSAO = Izvestiya Spetsialnoj Astrofizicheskoj Observatorii
IVUZR = Izvestiya Vysshikh Uchebnykh Zavedenij
JRASC = Journal of the Royal Astronomical Society of Canada
MN = Monthly Notices of the Royal Astronomical Society
MRAS = Memoires of the Royal Astronomical Society
Nat = Nature
NatPS = Nature Physical Science
Obs = Observatory

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PASA = Proceedings of the Royal Astronomical Society of Australia
PASJ = Publications of the Astronomical Society of Japan
PASP = Publications of the Astronomical Society of the Pacific
PRL = Physical Review Letters
Soviet Astron. = Soviet Astronomy
Sci = Science
SR = Space Research
Sup = Supplement
VA = Vistas in Astronomy

2. CONTINUUM RADIATION FROM THE GALAXY

A. *General Background*

New high sensitivity and high resolution maps have been published at a number of frequencies (**40, 50, 21, 1, 28, 7, 18, 19, 75, 72, 71, 70, 66, 64, 51, 36**), and spectral indices have been improved. The most important results have appeared after nonthermal radio and X-Ray surveys were compared. Now we have a strong and very direct confirmation of the old hypothesis on the secondary production of ultra-relativistic electrons responsible for long wavelength radio emission of our Galaxy. Very low (**61, 47, 4, 3, 12**) and very high (**5, 39**) frequency observations of the Milky Way should be mentioned specially, both being sensitive to the amount of ionized gas. Results of surveys of continuum emission polarization can be found in (**77, 9, 48**), the structure of magnetic field being analysed in (**78, 73, 55**).

B. *Supernovae*

A large number of very detailed maps have been produced (**37, 34, 33, 67, 24, 69, 15, 42, 38, 15, 17**), many of these containing important polarization information (**52, 4, 60, 59, 53**). Statistics and evolution are discussed in (**22, 65, 43, 35, 20, 2, 14, 13**). A good review of the present state of the whole problem can be found in (**61**).

C. *Galactic Centre*

Much better high resolution maps have appeared due to cooperation between observatories (**68, 6, 30, 31, 44, 49, 54, 56, 57, 63, 25, 26, 76, 11, 10**). An attempt to find pulses from Sgr A sources has been made, but without success (**27, 23, 41, 42**). New important steps have been made by discovering SNR (Sgr A, West) and broad recombination line in Sgr A. The review of all new observations of this complex region can be found in (**57**).

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2. Akhundova *et al.* 74*Astrofiz***10**, 85.
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4. Antonow. 73*IVUZR***16**, 759.
5. Ariskin *et al.* 74*Astron.Tsirk.* No 833, 6.
6. Ariskin *et al.* 74*AJ***51**, 5, 916.
7. Ariskin. 73*AJ***50**, 2, 283.
8. Baker. 74*ApJ***194**, 271.
9. Baker *et al.* 74*MN***167**, 581.
10. Balick *et al.* 74*ApJ***192**, 325.
11. Berulis *et al.* 73*AJ***50**, 2, 270.
12. Balick *et al.* 74*ApJ***194**, 265.
13. Brown. 73*ApJ***180**, 359.
14. Cavallo *et al.* 74*ASS***30**, 409.
15. Chevalier *et al.* 74*ApJ***192**, 454.
16. Clark *et al.* 73*Nat***246**, 5427.
17. Clark *et al.* 75*AJP Sup***37**, 75.
18. Clark *et al.* 75*AJP Sup***37**, 1.
19. Cowsik *et al.* 74*Mitt.Astron.Ges.***35**, 224.
20. Cowsik *et al.* 73 *13th Int.Cosm.Ray. Conf.Denver.Colo.***1**, 414.
21. Dellaporta. 74*IAU Symp,* 189.
22. Day. 73*CSIRO Div.Radiophys.Res. Activ.*
23. Dickel *et al.* 74*BAAS***6**, 314.
24. Dube *et al.* 73*NatPS***245**, 141, 17.
25. Duin *et al.* 74*IAU Symp.***60**, 355.
26. Dulk *et al.* 72*AJP***25**, 429.
27. Dulk *et al.* 74*Nat***248**, 5443, 33.
28. Edwards *et al.* 74*Nat***247**, 5441, 444.

29. Felli *et al.* 73*AA*29, 1, 129.
30. Fujimoto *et al.* 74*PASJ*26, 399.
31. Gezari *et al.* 73*ApJ*179, L67.
32. Gordon 74*IAU Symp.*60, 477.
33. Green 74*AA Sup*18, 2, 267.
34. Gull 73*MN*162,135.
35. Gull 75*MN*171, 237.
36. Gulliford 74*ASS*31, 241.
37. Haslam *et al.* 74*AA Sup*13, 359.
38. Hill 74*MN*169, 59.
39. Hirabayashi 74*IAU Symp.*60, 353.
40. Hirabayashi 74*IAU Symp.*60, 187.
41. Hirabayashi 74*PASJ*26, 2, 263.
42. Hughes *et al.* 73*Nat*242, 5393, 105.
43. Hughes *et al.* 74*IAU Symp.*60, 401.
44. Johnson 74*ApJ*194, 337.
45. Jones 74*AA*30, 1, 37.
46. Jones *et al.* 74*AJP*5, 687.
47. Sofue 73*PASJ*25, 207.
48. Zhouckl 73*IVUZR*16, 5, 754.
49. Kapustin *et al.* 73*IVUZR*16, 1325.
50. Kapitzky *et al.* 74*ApJ*188, 27.
51. Keen 73*AA*24, 2, 229.
52. Kelly 74*MN* 33.
53. Kundu *et al.* 74*AJ*79, 132.
54. Kundu *et al.* 73*AJ*78, 170.
55. Little 74*IAU Symp.*60, 491.
56. Manchester 74*ApJ*188, 644.
57. Mezger 74*ESO/SRC/CERN Conf.Res. Program, New Large Telescopes Geneva Proc.*
58. Mezger *et al.*
59. Milne *et al.* 74*AJP*27, 549.
60. Milne *et al.* 74*IAU Symp.*60, 335.
61. Mills 74*IAU Symp.*60, 311.
62. Milogradov-Turin *et al.* 74*MN*161, 269.
63. Mongain 73*NatPS*242, 122, 136.
64. Rougoor *et al.* 74*AA*33, 3, 459.
65. Shakeshaft 74*IAU Symp.*60, 185.
66. Shklovskii 74*IAU Symp.*60, 373.
67. Sironi 74*MN*166, 2, 345.
68. Slee *et al.* 74*IAU Symp.*60, 347.
69. Soboleva 74*AZh*51, 1341.
70. Strom *et al.*
71. Price 74*IAU Symp.*60, 637.
72. Price 74*AA*33, 33.
73. Taylor 73*Proc.IEEE*61, 4, 469.
74. Vajsberg 74*AZh*51, 922.
75. Velusamy *et al.* 74*AA*32, 375.
76. Webster 74*MN*166, 2, 355.
77. Whiteoak *et al.* 73*AL*13, 14, 205.
78. Wilkinson 73*MN*163, 2, 147.
79. Wilkinson *et al.* 74*MN*167, 593.

D. *H II Regions Radio Emission*

I. *Gaseous Nebulae*

During the last three years (73–75) observations of continuum radio emission from H II regions in a vast range of wavelengths (1 mm to 75 cm) have been carried out. In comparison with the preceding three years a significant increase in the amount of observational data obtained at mm wavelengths is quite evident. Not only bright giant H II regions but also faint optically visible nebulae have been investigated. The study of brightness distribution of different types of H II regions with high and intermediate resolution goes on, however, some new features may be distinguished. Special attention has been paid to the statistical study of relations between compact and large-scale structures within H II regions, also between compact H II regions, OH/H_2O masers and bright infrared emission sources. In this connection it should be emphasized that investigation of molecular lines and infrared emission of H II regions has been very intensive.

The intensive study of recombination radio lines of excited hydrogen, helium and carbon, and maybe some heavier elements is continued. Statistical investigation of electron temperatures obtained from the data on recombination radio lines has revealed that the electron temperature of H II regions depends on the galactic radius.

Some studies of the effect of electron temperature and density fluctuations, and gradients on the continuum and recombination line emission of H II regions have been performed.

The first high resolution survey of continuum radiation from extragalactic H II regions in the nearby galaxy M 33 has been made.

II. *Planetary Nebulae*

The intensive study of radio continuum in cm and dm wavelength ranges is continued. Detailed radio maps of a great number of planetary nebulae have been obtained in the continuum with a resolution as small as 2″. In a number of planetary nebulae recombination radio lines of excited hydrogen have been observed.

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III. *Radio Stars*

Radio emission of several new objects of MWC 349 type, peculiar stars with forbidden emission lines and large infrared excesses, have been revealed. It seems that new-type objects have appeared – Radio ETELS (Early-Type Emission Line Stars). Radio emission is supposed to be generated in vast gaseous envelopes, some kind of protoplanetary nebulae formed as a result of mass loss by the central star.

Complex investigation of X-ray, optical and radio emission of X-ray stars is continued.

H II REGIONS

1. *Surveys. Flux densities*

1.1	Amirkhanyan *et al.* 73*Astron. Circ.* **802**, 7.	14.4
1.2	Churchwell *et al.* 73*AA* **23**, 117.	2.695
1.3	Terzian *et al.* 73*PASP* **85**, 806.	2.175
1.4	Blair *et al.* 74*PASP* **86**, 599(a).	
1.5	Clark *et al.* 74*AJP* **27**, 713.	0.408
1.6	Clegg *et al.* 74*Nat* **249**, 530.	77.5
1.7	Bfanov *et al.* 74*AZh* **18**, 4.	77.5
1.8	Fannti *et al.* 74*AA Sup* **16**, 43.	0.408
1.9	Felli *et al.* 74*ASS* **26**, 901.	1.400
1.10	Klein 74*AJ* **79**, 139.	21.84
1.11	Rather 74*PASP* **86**, 601	21.4
1.12	Zabolotnyj *et al.* 75*Pisma AZh* **1**, 1.14	(300-60)

2. *Surveys. Structure*

2.1	Berulis *et al.* 73*Soviet Astron.* **17**.	36.5
2.2	Israel *et al.* 73*AA* **27**, 143.	1.4
2.3	Felli *et al.* 74*AA* **31**, 431.	8.085
2.4	Turner *et al.* 74*ApJ* **194**, 279.	2.7
2.5	Cogdell 75*ApJ* **196**, 363.	150
2.6	Wink *et al.* 75*AA* **38**, 109.	2.695 8.085

3. *Brightness distributions of single H II regions. Overall structure.*

3.0	Bogod *et al.* 73 *Soviet Astron.* **17**, 47 = *AZh* **52**, 72.	M17, OriA
3.1	Ellis. 73*PASA* **2**, 158.	Gum Neb
3.2	Johnston *et al.* 73*AJ* **78**, 235.	Omega
3.3	Jones 73*AJP* **26**, 545.	Car Neb
3.4	Kaifu *et al.* 73*PASJ* **25**, 129.	OriA
3.5	Kislyakov *et al.* 73*IVUZR* **16**, 774.	OriA
3.6	Rarijskij *et al.* 73*IVUZR* **16**, 778.	M1-19
3.7	Terzian *et al.* 73*AJ* **78**, 804.	Cyg X
3.8	Velusamy *et al.* 73*AJ* **78**, 31.	S101
3.9	Ade *et al.* 74*ApJ* **189**, 123.	M42, DR-21
3.10	Baars *et al.* 74*IAU Symp.* **60**, 219.	
3.11	Caswell *et al.* 74*AA* **32**, 209.	OriA, OriB IC434
3.12	Elias *et al.* 74*PASP* **86**, 599.	DR-21
3.13	Scalize *et al.* 74*Nat* **225**, 663.	Car Neb
3.14	Chaisson *et al.* 75*ApJ* **199**, 647.	Trifid Neb
3.15	Gardner *et al.* 75*MN* **171**, 29P.	G0.55-0.85
3.16	Werner *et al.* 75*ApJ* **199**, L185.	DR-21
3.17	Goudis 75*ASS* **33**, 103.	IC1318
3.18	Zeilik III *et al.* 75*ApJ* **199**, 401.	G45.1+0.1 G45.5+0.1
3.19	Walmsley *et al.* 75*AA* **41**, 121.	S206, 209

4. *Compact structure in H II regions*

4.1	Harris 73*MN* **162**, 5P.	DR-21
4.2	Martin 73*MN* **163**, 141.	NGC7538
4.3	Martin 73*Obs* **93**, 164.	
4.4	Sullivan III *et al.* 73*AA* **29**, 369.	W3
4.5	Broderick *et al.* 74*ApJ* **192**, 343.	G351.6-1.3
4.6	Harris 75*MN* **170**, 139.	K3-50

5. *Compact H II regions associated with OH/H_2O masers and IR sources*

5.1	Baldwin *et al.* 73*Nat*241, 38	W3(OH)
5.2	Goss *et al.* 73*AA*29, 435.	ON-2 OHO739-1.4
5.3	Matsakis 73*BAAS*5, 450.	M78,S269 IC2162
5.4	Winnberg *et al.* 73*NatPS*243,78.	ON-1 OH069.5-10
5.5	Brown 74*ApJ*194,L9.	AFCRL809-2992
5.6	Harris 74*MN*166, 29.	
5.7	Wendker *et al.* 74*AA*33, 157.	

6. *Compilative and review papers, discussions*

6.1	Angerhofer *et al.* 73*Mitt. Astron. Ges.* 32, 269.	Cat.opt.vis. H II reg.
6.2	Wilson *et al.* 75*Lecture Notes Phys.* 42, Springer.	
6.3	Balick *et al.* 74*PASP*86, 616.	OriA, Structure
6.4	Churchwell. 74*IAU Symp.* 60, 195	review
6.5	Habing 74*Proc. NATO Adv. Study Inst.* 91.	review
6.6	Terzian 74*VA*16,279.	review
6.7	Goudis 75*ASS*35, 409.	OriA
6.8	Goudis 75*ASS*36, 79.	OriA
6.9	Goudis 75*ASS*36, 105.	OriA
6.10	Gorschkov *et al.* 75*AZh*52, 538.	

7. *Electron temperature in H II regions*

7.1	Pyatunina *et al.* 73*AZh*50, 507.	$T_e$distr
7.2	Simpson 73*PASP*85, 479.	OriA
7.4	Churchwell *et al.* 75*AA*38, 451.	T_e-gal.rad. dep.
7.5	Pyatunina 75*Izv. SAO*7, 101.	$T_e$distr.

8. *Spectra of H II regions*

8.1	Salem *et al.* 74*MN*167, 493.	
8.2	Salem 74*MN*167, 511.	
8.3	Olnon 75*AA*39, 217. *(see also 7.1, 6.9).*	

9. *Infrared emission of H II regions*

9.1	Frogel *et al.* 72*ApJ*178, 667.	S138,152, 270.
9.2	Wynn-Williams *et al.* 72*MN*160, 1.	W3
9.3	Becklin *et al.* 73*ApJ*182, L7.	OriA
9.4	Becklin *et al.* 73*AL*13, 147.	W49 (OH/H_2O)
9.5	Becklin *et al.* 73*ApJ*182, L125	G333.6-02
9.6	Emerson *et al.* 73*ApJ*184, 401.	
9.7	Erickson *et al.* 73*ApJ*183, 535.	OriA
9.8	Johnston 73*ApJ*180, L7.	
9.9	Persson *et al.* 73*BAAS*5, 318.	
9.10	Rieke *et al.* 73*ApJ*183, L67.	Gal.Cen. NGC253
9.11	Swift *et al.* 73*IAU Symp.* 52, 453.	OriA
9.12	Wynn-Williams *et al.* 73*IAU Symp.* 52, 459.	
9.13	Aannestad. 74*BAAS*6, 263.	
9.14	Beetz *et al.* 74*AA*34, 335.	W3
9.15	Bergeat *et al.* 74*AA*30, 181.	DR-21
9.16	Dyck *et al.* 74*ApJ*194, 57.	OriA
9.17	Fazio *et al.* 74*ApJ*192, L23.	OriA
9.18	Frogel *et al.* 74*ApJ*192, 351.	Copm.IR-source.
9.19	Grasdalen 74*ApJ*193, 373.	W12
9.20	Harper 74*ApJ*192, 557.	M42,NGC 2024
9.21	Houck *et al.* 74*ApJ*193,L139.	OriA
9.22	Lemke *et al.* 74*AA*32, 231.	OriA, map
9.23	Lunel *et al.* 74*AA*34, 299.	S157
9.24	Mezger *et al.* 74*AA*32, 269.	
9.25	Olthof *et al.* 72*IEAM*2, 243.	
9.26	Panagia 74*ApJ*192,221.	
9.27	Pipher *et al.* 74*ApJ*193, 283	G30. 8-0.0
9.28	Pipher *et al.* 74*BAAS*6, 335	G29.9-0.0
9.29	Schaak *et al.* 74*BAAS*6, 329.	OriA
9.30	Ward *et al.* 74*BAAS*6, 329(a).	OriA
9.31	Ward *et al.* 74*Nat*252, 27.	OriA
9.32	Wynn-Williams *et al.* 74*PASP*86, 5.	
9.33	Wynn-Williams *et al.* 74*ApJ*187, 473.	
9.34	Wynn-Williams 74*IAU Symp.* 60, 259.	
9.35	Soifer *et al.* 74*ApJ*191, L83.	OriA, NGC2024
9.36	Fazio *et al.* 75*ApJ*199, L117.	W3

9.37	Harvey *et al.* 75*ApJ***196**, L31.	W51 map
9.38	Soifer *et al.* 75*ApJ***199**, 663.	G29.9-0.0
9.39	Ward. 75*ApJ***200**, L41.	OriA spectrum
9.40	Thum *et al.* 75*AA***41**, 467. *(see also 3.9, 5.3, 5.5, 6.7)*	DK-21

10. *H II regions in nearby galaxies*

10.1	Israel *et al.* 74*AA***32**, 363.	1.415
10.2	Spencer *et al.* 74*IAU Symp.* **60**, 229.	
10.3	Andrew. 75*AA***39**, 421.	H_2O em
10.4	Israel *et al.* 75*AA***40**, 421.	0.61, 1.415, 4.995, M101

PLANETARY NEBULAE

1. *Surveys. Flux densities*

1.1	Johnston. 73*CIAL***18**, 121.	31.85
1.2	Sistla *et al.* 73*BAAS***5**, 424(a).	15.5
1.3	Terzian *et al.* 73*AJ***78**, 875	0.430
1.4	Cahn *et al.* 74*AJ***79**, 128.	2.7,8.1
1.5	Sistla *et al.* 74*ApJ***192**, 165.	15.5
1.6	Milne *et al.* 75*AA***38**, 183.	5.0
1.7	Scott 75*MN***170**, 487.	5.0

2. *Structure*

2.1	Balick *et al.* 73*ApJ***182**, L117.	NGC7027
2.2	Kaftan-Kassim 73*CIAL***18**, 129.	1C2149, NGC 6543, 7662
2.3	George *et al.* 73*BAAS***5**, 424.	
2.4	Scott. 73*MN***161**, 35P.	NGC7027
2.5	Terzian *et al.* 73*ApJ***188**, 257.	
2.6	Georfe *et al.* 74*AA***35**, 219.	NGC40, 6543 7662
2.7	Sistla *et al.* 74*BAAS***6**, 425.	NGC3568
2.8	Willis *et al.* 74*AA***36**, 455.	NGC6543
2.9	Sistla *et al.* 74*MN***166**, 17.	ICZ149
2.10	Purton *et al.* 75*ApJ***195**, 479.	M2-9

3. *Infrared emission*

3.1	Becklin *et al.* 73*AL***15**, 87.	NGC7027
3.2	Danziger 73*ApJ***184**, L29.	NGC6302
3.3	Cohen *et al.* 74*ApJ***193**, 401.	survey
3.4	Khromov 74*AZh***51**, 335.	
3.5	Telesco *et al.* 74*BAAS***6**, 464.	NGC7027
3.6	Boksenberg *et al.* 75*MN***171**, 395.	NGC6543
3.7	Danziger 75*AA***38**, 475.	NGC6210
3.8	Khromov 75*Pisma AZh***8**, 16.	evol.eff.in
3.9	Merrill *et al.* 75*ApJ***200**, L37.	NGC7027

4. *Compilative and review papers*

4.1	Higgs 73*MN***161**, 313.	spectra
4.2	Higgs 73*CIAL***18**, 89.	spectra
4.3	Higgs 73*CIAL***18**, 101.	
4.4	Miller 74*ARAA***12**, 331,	review
4.5	Thomson 74*VA***16**, 309.	review

RADIO STARS

A. *Radio emission of OB stars*

1. *Observations*

1.1	Altenhoff *et al.* 73*Nat***241**, 37.	L Ori,HBV475, MWC349
1.2	Altenhoff *et al.* 73*IAU Circ.* 2549.	V1016Cyg
1.3	Altenhoff *et al.* 73*IAU Circ.* 2569.	MWC137, LkHL101
1.4	Baldwin *et al.* 73*Nat***241**, 38.	MWC349
1.5	Feldmann *et al.* 73*IAU Circ.* 2543.	V1016Cyg
1.6	Feldman *et al.* 73*IAU Circ.* 2549.	HD167362, VY2-2
1.7	Feldman *et al.* 73*IAU Circ.* 2560.	M2-9
1.8	Feldman *et al.* 73 *NatPS***245**, 7.	M1-11 HD37806
1.9	Feldman *et al.* 73*NatPS***245**, 39.	MWC957.
1.10	Gregory *et al.* 73*NatPS***242**, 101.	MWC349

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1.11 Gregory *et al.* 73*IAU Circ.*2556. R Aquarii
1.12 Greenstein. 73*ApJ***184**, L23 MWC349
1.13 Hjellming *et al.* 73*NatPS***242**, 84. MWC349
1.14 Hughes *et al.* 73*NatPS***242**, 116. RY Scuti
1.15 Marsch *et al.* 73*IAU Circ.* 2565. M1-11, HD37806
1.16 Morrow *et al.* 73*IAU Circ.* 2567. MWC957
1.17 Purton *et al.* 73*NatPS***245**, 5. V1016Cyg
1.18 Purton *et al.* 73*NatPS***245**, 6. VY2-2, HD167362
1.19 Seaquist *et al.* 73*IAU Circ.* 2563 V1016Cyg VY2-2
1.20 Wendker *et al.* 73*NatPS***245**, 118. P Cyg
1.21 Gregory *et al.* 74*Nat***247**, 532. R Aquarii
1.22 Wright *et al.* 74*Nat***250**, 715. Hen 1044

2. *Interpretation*

2.1 Barrata *et al.*74*ApJ*187, 651.
2.2 Braes 74*IAU Symp.* **60**, 377.
2.3 Ciatti *et al.* 74*AA***34**, 181.
2.4 Fitzgerald *et al.* 74*ApJSup***28**, 147.
2.5 Marsch *et al.* 74*JRASC*68, 265(a).
2.6 Purton *et al.* 74*BAAS*6, 457.
2.7 Ciatti *et al.* 75*AA***38**, 435.
2.8 Wright *et al.* 75*MN***170**, 41.

B. *Radio emission of X-ray binaries*

1. *Observations*

1.1 Hjellming *et al.*72*ApJ*178, L139. Per
1.2 Aller *et al.* 73*NatPS***245**, 40. Cyg X-3
1.3 Bash *et al.* 73*NatPS***241**, 93. Cyg X-3
1.4 Braes *et al.* 73*NatPS***242**, 66. Cyg X-3
1.5 Gregory. 73*JRASC*67, 199. Cyg X-3
1.6 Gregory *et al.* 73*BAAS*5, 394(a). Cyg X-3
1.7 Hjellming *et al.* 73*Nat***242**, 250. Per
1.8 Hjellming *et al.* 73*NatPS***243**, 81. AR Lac Cyg X-2
1.9 Icke. 73*NatPS***244**, 132. Cyg X-3
1.10 Pooley *et al.* 73*Nat***244**, 270. Per
1.11 Becklin *et al.* 74*ApJ***192**, L119. Cyg X-3
1.12 Daishido *et al.* 74*Nat***251**, 36. Cyg X-3
1.13 Gibson *et al.*74*PASP*86, 652. CC Cas, AR Lac
1.14 Hjellming *et al.* 74*ApJ***194**,L13. Cyg X-3
1.15 Hughes *et al.*74*ApJ***191**, 749. Cyg X-3
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D. *Stars with extended coronae*

1. Wendker *et al.* 73*NatPS***245**, 118. P Cyg
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E. PULSARS

At the present time the initial stage of 'pulsar accumulation' is being replaced step by step by the stage of their thorough investigation. The state of the matter is reflected in the papers published during the period under review (1), (2). The principal observational and some theoretical results are presented in (3). The most complete catalogue, including 147 pulsars can be found in (4). The bibliography presented below contains references mainly to observational works.

Information on new pulsar discoveries is contained in (5)–(11). The most remarkable fact is the discovery of a pulsar in a binary system (12).

Pulsar distances, proper motions, positions are found in (13)–(15). Pulsar periods, period derivatives are in (16)–(22). Period discontinuities in slow pulsars: (23), (24). Pulse profiles, their changes and variability: (25)–(33). Spectra, polarization in pulses, subpulses, precursors: (34)–(65). Pulsars and study of interstellar medium, halos, scintillations etc: (67)–(81). VLBI results are in (82)–(84).

As to the nature of pulsar phenomenon, it is only generally accepted now that a pulsar is a neutron star and mechanisms of radio emission are coherent. The lack of complete clarity is mainly due to the insufficiency of knowledge of matter in the extreme conditions. The general characteristic of the magnetosphere of pulsars is presented in (85). The radiation mechanisms suggested and their discussion can be found in (86)–(92). A survey on the inner structure of neutron stars is in (93).

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3. NEUTRAL HYDROGEN, 21 cm (GALACTIC AND EXTRAGALACTIC) AND RECOMBINATION LINES

(I. V. Gossachinskij, B. Zuckerman)

Three new general sky surveys with a resolution of up to 2 km s^{-1} have appeared. Practically the entire sky has been observed with an angular resolution of 0°.5, and large regions of the sky with a resolution of 10°. The results come rather slowly due to an extremely large amount of information and slow process of data reduction.

All the papers on the Galaxy during the last three years have shown a keen interest in (a) the very small-scale structure and movement of interstellar gas, and (b) very large-scale phenomena, including the Galactic centre region, large features at high latitudes, and H I streams in the local system. Some new observations have been made of H I complexes around clusters, H II regions, SNR, dust clouds, spurs. Very intensive observations of the H I absorption line and of the two-component structure of gas have been made. The deuterium line has been found in the spectrum of SGRA with much greater confidence than any before.

Much progress can be seen in the accumulation of data on the H I line in external galaxies.

Some puzzling results are available now on the H I absorption line in the direction of quasars. Many H I maps of nearby galaxies have been synthesized with a resolution of 0'.5, and integrated properties of about 200 more distant galaxies have been obtained.

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(*see also* **7.14, 8.12**)

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(*see also* **4.8, 5.7, 6.4, 7.2, 9.4, 9.10, 9.12, 10.1, 10.5, 10.8, 10.9, 10.12**)

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16.6	Guibert 73*AA Sup*12, 263.	M31
16.7	Wright 73*ApJ*179, 453.	M33 outer part
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16.9	Erkes *et al.* 73*BAAS*5, 430.	SMC
16.10	De Young *et al.* 73*ApJ* 185, 809.	Per-A
16.11	Guibert 74*AA*30, 353.	M31
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17.9	Emerson *et al.* 73*MN*165, 9P.	M31
17.10	Emerson 74*MN*169, 607.	M31
17.11	Rogstad *et al.* 74*ApJ*193, 309.	M83
17.12	Allen *et al.* 74*IAU Symp.* 58, 425.	M101, NGC5383
17.13	Rots *et al.* 74*AA*31, 245.	M81
17.14	Shostak *et al.* 74*AA*31, 97.	IC10
17.15	Gottesman *et al.* 75*ApJ* 195, 23.	M81
17.16	Weliachev 74*ApJ*191, 639.	abs. M82

18. *Galaxies in groups and clusters, intergalactic medium*

18.0	Davies *et al.* 73*MN*165, 231.	gal.from. Virgo cl.
18.1	Mirabel *et al.* 73*AA*22, 437.	tail from SMC
18.2	Smart 73*AA*24,171.	intergalactie Coma cl.
18.3	Balkowski *et al.* 73*AA*25, 319.	Stefan quintet
18.4	Brown *et al.* 73*ApJ*184, L7.	abs.3C286
18.5	Gottesman *et al.* 73*ApJ* 184, L1.	abs.QSS
18.6	Shostak 74*ApJ*187, 19.	Stefan quintet
18.7	Wright *et al.* 74*AA*36, 441.	u.l.cl.
18.8	Bottinelli *et al.* 74*AA*36, 461.	gal. in Coma cl.
18.9	Mathewson 74*IAU Symp.* 60, 617.	Mag.stream
18.10	Davies 74*IAU Symp.*58, 119.	out of gal-s
18.11	Mathewson *et al.* 74*ApJ* 190, 291.	Mag.stream
18.12	De Young *et al.* 74*ApJ* 189, 1.	u.l. in cl.
18.13	Huchtmeier *et al.* 75*AA* 41, 477.	
18.14	Winter *et al.* 75*MN*172, 1.	interacting gal-s
18.15	Cohen *et al.* 75*MN*170, 23P.	Mag.stream
18.16	Mathewson *et al.* 75*ApJ* 195, L97.	Sculptor group
18.17	Field 74*IAU Symp.* 63, 13.	Intergal. medium, review

19. *Recombination H-lines, surveys and review papers*

19.1	Simpson 73*ASS*20, 187.	Stark, survey
19.2	Gordon 74*IAU Symp.*60, 151.	g.c.review
19.3	Guljaev *et al.* 74*AZh*51, 1237.	OriA review
19.4	Ahmad 74*ApJ*194, 503.	theory
19.5	Terzian *et al.* 74*IAU Symp.* 60, 241.	review
19.6	Batty 74*MN*168, 378.	survey
19.7	Gull *et al.* 74*ApJ*192, 63.	survey
19.8	Gordon *et al.* 74*ApJ*192, 337.	survey
19.9	Parrish *et al.* 75*ApJ*198, 349.	survey
19.10	Hoangh-Binh 72 *(see ref. 1.2)*, 367.	line width
19.11	Pyatunina 73*Soviet Astron.*17, 5.	grad T_e N_e
19.12	Kerr *et al.* 74*IAU Symp.* 60, 81.	review
19.13	Berulis *et al.* 75*Pisma AZh*1, 28.	H56α H II-5
19.14	Spencer *et al.* 73*BAAS*5, 452.	H246α, 247α H I-5
19.15	Parrish *et al.* 73*BAAS*5, 452.	H226α, 248α H II-3

20. *Recombination H-lines in H II regions*

20.0	Parrish *et al.* 72*ApJ*178, 673.	H221α, H248α in W51
20.1	Matthews *et al.* 73*MN*165, 173.	H 166α g.c.
20.2	Lada *et al.* 73*ApJ*183, 479.	H 94α NGC7938
20.3	Cato. 73*Onsala Obs. Res.Note*, No. 114.	H183α, 230β H II-5
20.4	Terzian 73*AJ*78, 894.	H109α Cyg X
20.5	Pedlar *et al.* 73*MN*165, 381.	H166α Ros, NAm
20.6	Chaisson 73*ApJ*186, 545.	H94α, 148δ OriA
20.7	Brown *et al.* 73*ApJ*185, 843.	H166α, g.c.
20.8	Waltmann 73*ApJ*185, L35.	H42α OriA
20.9	Chaisson 73*ApJ*182, 767.	OriB
20.10	Waltman *et al.* 73*ApJ*182, 489.	H66α
20.11	Pankonin *et al.* 73*ApJ* 180, L113.	H247α., 248α, W49A
20.12	Sullivan 73*AA*29, 369.	H166α W3
20.13	Lockman *et al.* 73*ApJ*182, 25.	H159αGal. Cent.
20.14	Pedlar *et al.* 74*MN*168, 577.	H166α in H2-3
20.15	Macleod *et al.* 74*JRASC* 68, 266.	H85α W12
20.16	Viner *et al.* 74*BAAS*6, 349.	W49 A, B
20.17	Pankonin *et al.* 74*AA*37, 411.	H221α, 247α, 248α, W51, W49

20.18	Pauls 74*AA*34, 327.	H109α, 137β, g.c.
20.19	Huchtmeier 74*AA*32, 335.	H90α RCW 38
20.20	Balik *et al.* 74*ApJ*188, 45.	H85α OriA
20.21	Gardner *et al.* 75*AL*16, 29.	H134α W33
20.22	Gardner *et al.* 75*MN*171, 29P.	H110α RCW142
20.23	Brown *et al.* 75*ApJ*200, L155.	g.c
20.24	Churchwell *et al.* 74*AA* 32, 283.	
20.25	Macleod *et al.* 75*AA*42, 195.	H85α NGC2024
20.26	Thonnard 73*BAAS*5, 451.	H67α OriA
20.27	Zeilik *et al.* 73*BAAS*5, 451.	H92α M16
20.28	Zeilik *et al.* 74*AJ*79, 786.	H92α M16
20.29	Willson *et al.* 74*BAAS*6, 350.	H110α M20
20.30	Hoangh-Binh *et al.* 74*AA* 35, 49.	
20.31	Lockman, Brown 75*ApJ* 201, in press.	

21. *Recombination H-lines in other galactic object*

21.1	Bignell 73*ApJ*186, 889.	H166α W44 SNR
21.2	Cesarsky *et al.* 73*ApJ*184, 83.	SNR
21.3	Downes 74*AA*34, 133.	H134α SNR
21.4	Chaisson 74*ApJ*189, 69.	SNR
21.5	Terzian *et al.* 74*AJ*79,1018.	planet.neb
21.6	Bignell 74*ApJ*193, 687.	planet. neb
21.7	Higgs 74*JRASC*68, 295.	widths, planet. neb
21.8	Mcgee *et al.* 74*AJP*27, 729.	H109α, LMC
21.9	Pankonin 75*AA*38, 445.	H248α SNR

22. *Recombination H-lines in H I and dust clouds, and in diffuse medium*

22.0	Gordon 72*CIAL*17, 409.	
22.1	Gordon 73*ApJ*184, 77.	dark cloud
22.2	Davies *et al.* 73*MN*165, 149.	H166α diffuse
22.3	Pedlar 73*Obs*93, 166.	diffuse, review
22.4	Lackson *et al.* 73*BAAS*5, 331.	H110α diffuse
22.5	Zuckerman 74*IAU Symp.* 60, 45.	H I
22.6	Chaisson *et al.* 74*ApJ*189, 227.	H I
22.7	Zuckerman *et al.* 74*ApJ* 190, 35.	H I
22.8	Jackson *et al.* 75*ApJ*196, 723.	H110α diffuse

23. *Recombination lines from heavier elements*

23.1	73*BAAS*5, 451.	
23.2	Brown *et al.* 74*ApJ*189, 253.	dark cloud
23.3	Zuckerman *et al.* 74*ApJ* 190, 35.	
23.4	Dupree 74*ApJ*187, 25.	
23.5	Chaisson 74*ApJ*191, 411.	
23.6	Knapp *et al.* 75*ApJ*196, 167. (*see also* **20.6**, **20.18**, **21.3**)	
23.7	Brown *et al.*74*AA* 32, 83.	C dark cloud
23.8	Chaisson 73*BAAS*5, 451.	heavy el.
23.9	Dupree 73*BAAS*5, 22.	carbon

4. RADIOASTRONOMY INVESTIGATIONS OF INTERSTELLAR MOLECULES

(V.K. Khersonsky)

It is possible to claim that the interest in the subject mentioned above is continuously increasing. For the last three years 9 new interstellar molecules and some radio lines (which have not yet been identified) have been discovered. The total number of molecules observed in the microwave region is 31. Most of the interstellar molecules are observed in our Galaxy. However some reports deal with the detection of microwave molecular radiation from extragalactic sources.

The aim of the present review is to give a complete bibliography of papers published in 1973, 1974, and partly in 1975.

A. *Carbon monoxide (CO) lines*

Carbon monoxide has been studied at the 2.6-mm wavelength (I = 1-0 transition) in the following objects: the galactic center (**36, 38, 214, 215, 304, 305, 314, 315**); Sgr B2 (**411**); the

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Orion nebula (**101, 124, 146, 212, 276, 362, 411, 413**); Cyg X-region (**84**); in the spectrum of ρ Ophiuchi (**102**); IC 1396 (**223**): W49, W51 (**312**); W3, NGC 7538 (**397**); M17 (**202**); M82, NGC 253 (**282**); M82, NGC 253, M31, M51 (**345**), and some other sources (**77, 128, 195, 196, 239**). Special studies of radiation have been carried out for optically dark clouds (**18, 19, 225, 319**); dust clouds (**103, 240, 241**); the sources associated with H II regions (**90, 135, 229**); and the star formation regions (**222**). General investigation of the distribution of CO molecules in the Galaxy has been made (**309, 310, 399, 400**). The structure and the detailed maps of some clouds have been studied (**124, 146, 212, 214, 215, 319**). The significance of CO in the cooling of interstellar gas clouds and the collapse of massive clouds has been discussed (**18, 19, 81, 134, 222, 224, 228, 311, 312, 355**). Molecules of $^{12}C\,^{17}O$ (**104**) and $^{13}C\,^{16}O$ (**135, 146, 202, 223**) have been observed. Emission in $I = 2 \rightarrow 1$ line of $^{12}C\,^{16}O$ and $^{13}C\,^{16}O$ has been investigated (**135, 270**). Laboratory measurements and calculations of CO frequencies have been reported (**227**). The cross-section of excitation of CO rotational levels in the CO-H_2 collisions has been studied (**64**).

B. *Hydroxyl radical (OH) lines*

General studies of OH lines have been carried out for the following objects: W3 (**143, 155, 192, 264**); W3A (**52, 53**); W10, W12 (**52, 53**); W22 (**52, 53, 325**); W28 (**266**); W30H (**230**); W31 (**394**); W37 (**409**); W41 (**140, 141**); W43 (**140, 141, 322, 409**); W49 (**155**); W49A, W49B (**265**); W49N (**230**); W51 (**100, 140, 141, 323, 324, 395**); W51A (**52, 53**); W73B (**99**); W75 (**408**); W75B (**299**); NGC 2068 (**169, 170**); NGC 2071 (**169, 170**); NGC 2438 (**145, 409**); NGC 4945 (**389**); NGC 6334 (**264, 327**); NGC 6334N (**192**); the galactic center (**206, 306**); SgrB2 (**155**); Orion A (**267**); the Orion nebula (**413**); ON-3 (**409**); V 1057 Cyg (**217, 218, 219**); Cyg X-region (**263**); VY CMa (**264**); NML Cyg (**8**); 3C 353 (**140, 141**); Southern Coal-sack (**32**); the Carina nebula (**85**); M20 (**328**), and some other sources (**5, 26, 27, 50, 51, 89, 160, 166, 173, 184, 185, 209, 286, 287, 303, 367, 369, 402**). Investigation of radiation from optically dark and dust clouds (**66, 67, 68, 190, 237, 256, 257, 393**), as well as from IR sources (**48, 398, 403**) has been carried out. Emission and absorption of excited rotational levels have been observed (**15, 121, 192, 261, 283, 284, 294, 299**). Some anomalies have been discussed (**367, 389, 390**). Observations of OH maser sources have been reported (**40, 75, 150, 189, 204, 205, 207, 230, 233, 357, 404**). Interferometry and VLBI measurements of OH sources have been made (**76, 155, 191, 192, 232, 279, 406**). The structure and the detailed distribution of the gas in the clouds have also been investigated (**65, 143, 144, 189, 216, 217, 218, 219, 220, 266, 303, 324**). Models for the OH masers have been proposed (**41, 42, 43, 45, 46, 47, 63, 78, 149, 182, 183, 203, 210, 261, 278, 326, 380**). Polarization of OH emission has been studied (**151, 217, 218, 219**). Zeeman splitting of spectral lines has been used to determine the magnetic field in the molecular clouds (**75**). Calculations of frequencies and probabilities of radio transition of OD have been performed (**186**); the estimate of the OD line strength towards the galactic center can be found in (**6**). The frequencies of the ^{17}OH lines have been reported (**376**).

C. *Water in (H_2O) lines*

H_2O emission has been observed in the following objects: W3, W49, W51 (**353**); W37, W43 (**409**); W75 (**353, 408**); Sgr B2 (**353, 378**); the Orion nebula (**353, 413**); VYCMa, ON1 (**353**); ON3 (**409**); NGC 2438 (**409**); NGC 6334 (**353**); far-infrared objects (**387**); OH sources (**407**) and some other sources (**17, 59, 142**). Emission lines of the regions associated with H II regions and IR stars have been studied (**11, 48, 49, 88, 220, 221**). Observations of H_2O masers have been reported (**91, 180, 181, 308, 357**). Interferometry and VLBI measurements of H_2O emission features have been made (**16, 20, 191, 193, 200, 255, 262, 280**). The sizes and the relative positions of some H_2O sources have also been determined (**189, 230**). The nature and models of H_2O masers have been discussed (**43, 45, 78, 79, 80, 210, 226, 344**). Polarization of emission has been studied (**24**). Detection of HDO in Orion A has been carried out (**373, 374**). (See also (**275**)). Laboratory measurements and calculations of frequencies and line strengths of H_2O have been reported (**82**).

D. *Hydrogen cyanide (HCN) lines*

There have been general studies of the HCN lines in the following objects: Sgr B2 (**178**); Orion nebula (**124, 146, 178, 263**); IC 1396 (**223**), in the direction of M8 (**126**) and M17 (**202**) and some other sources (**58, 59, 195, 196, 250, 251**). The papers (**58, 59, 199, 411, 413**) deal with the interpretation of observations. The structure of the emission regions in the Orion nebula has been discussed (**124, 146**). $H^{13}C^{14}N$ has been observed in the Orion nebula (**254**) as well as DCN (**347, 401**). Collisional excitation of the rotational levels of HCN by H_2 has been studied (**147**).

E. *Formaldehyde (H_2CO) lines*

Observations of emission and absorption of different rotational H_2CO lines have been made for the following objects: the galactic center (**306, 313**); SgrA (**235, 388, 392**); Sgr B2 (**289**), the Orion nebula (**86, 105, 107, 146, 156, 413, 425**), W3 (**245, 391**); W31 (**394**); W49, W51 (**312**); NGC 2264 (**244**); NGC 7538 (**95**) CasA (**360**); in the direction of M17 (**201, 202**); Cen A (**259**), the Carinal nebula (**119**); Southern Coalsack (**31**); Cyg X-3 (**243**) and some other sources (**111, 136, 158, 159, 160, 166, 369, 396**). Observations for para-H_2CO have been reported (**4, 176, 177**). (See also (**248**)). Investigations of H_2CO radiation have been carried out in optically dark clouds (**106, 244, 245, 246, 247, 393**), dust clouds (**69, 87, 103, 160, 256, 257, 354**) the regions associated with H II regions (**229, 410**). Interferometry measurements of formaldehyde line sources have been made (**111, 112**). Detailed maps and the structure of such clouds have also been discussed (**107, 146, 354**). Anomalies of H_2CO lines have been studied (**69, 103, 160, 273, 357, 412**). $H_2{}^{13}C^{16}O$ has been observed (**410**). H_2CO formation mechanisms have been discussed (**73, 242**).

F. *Other molecules*

CH radical. The molecule of CH has been observed (**288, 295, 296, 297, 298, 300, 301, 371, 372, 416**). CH radio line formation mechanisms have been discussed (**44, 120**). The problem of formation of CH and its abundances have been studied (**10, 21, 23, 98, 194, 331, 340, 341, 384**).

Silicon monoxide (SiO). SiO observations have been reported (**249, 348**). Interpretation of the observations can be found in (**134, 272, 413**). Maser emission sources have been investigated (**39, 171, 172, 175, 334, 358**). A model for explanation of pumping of molecular levels has been proposed (**198**). Precise laboratory measurements and calculations of SiO frequencies have been made (**227**).

Carbon monosulphide (CS). CS radiation has been observed (**146, 195, 196, 213, 223, 250, 251, 312**). The emission mechanism and the significance of this molecule in cooling of dense molecular clouds have been studied (**134, 228, 311, 312, 413**). Observations of $^{12}C^{33}S$ and $^{12}C^{34}S$ have been reported (**375**). Frequencies of radio transitions of all isotopic species have been measured in the laboratory (**227**).

Sulphur monoxide (SO). SO observations have been made in Sgr B2 (**178**), Ori A (**60, 61, 178**), IC 1396 (**223**), and in the direction of M17 (**202**). Unsuccessful searches for SO in W51, IRC + 10216 and Heiles cloud 4 have been reported (**4**). Observations have been interpreted and determination of the magnetic field by measurements of Zeeman splitting of the rotational levels of SO in Orion A has been carried out (**60, 61, 413**). The SO formation mechanism has been discussed (**260**). The frequencies of the SO radio transitions have been measured in the laboratory (**359**).

Carbonil sulphide (OCS). OCS lines have been observed in Sgr B2 (**4, 346**). Unsuccessful searches for OCS have been carried out (**4**) in W51, IRC + 10216 and Heiles cloud 4. Laboratory measurements and calculations of OCS line frequencies have been made (**231**). The OCS formation mechanisms have been discussed (**260**).

Ammonia (NH_3). This molecule has been observed in Orion A (**253, 254**), W3, W43, W51, Dr-21 (**253**), in cool and dark clouds (**56**), and in the direction of Hat Greek (**55**). The laboratory studies of NH_3 microwave spectra have been carried out (**277**).

Thioformaldehyde (H_2CS). The H_2CS microwave line has been investigated in Sgr B2 (**92, 93, 113, 321**). Formation reactions have been discussed (**260**).

Cyanoacetylen (HC_3N). Observations of HC_3N radiation in Sgr B2 have been made (**122, 236, 252, 346**). Results of unsuccessful searches for this molecule in W51, IRC + 10216, and Heiles cloud 4 have been reported (**4**).

Methanol (CH_3OH). Studies of CH_3OH lines in Sgr A, Sgr B2 (**197, 285**), Orion A (**12, 13**) and in the direction of Hat Greek (**55**) have been carried out. Observations and discussions of anomalous emission have been reported (**12, 13, 164, 208, 271**). Laboratory measurements of $^{12}CH_3OH$ and $^{13}CH_3OH$ frequencies have been made (**117, 154**).

Methylamine (CH_3NH_2). Observations of CH_3NH_2 in Sgr B2 and Orion A have been reported (**116, 178, 179**). Results of a search for this molecule are also presented in (**3**). Unsuccessful observations in W51, IRC + 10216 and Heiles cloud 4 have been made (**4**). Anomalies of CH_3NH_2 emission in Sgr B2 and Orion A have been discussed (**178, 179**).

There are also reports on the observations of the following molecules:

Cyanogen (CN) in the Orion nebula (**274, 368, 413**);
Silicon sulphide (SiS) in IRC + 10216 (**249**);
Hydrogen sulphide (H_2S) in the Orion nebula (**413**);
Sulphur dioxide (SO_2) in Sgr B2 (**336**);
Ethynyl radical (C_2H) in Sgr A, Sgr B2, Orion A, and soon (**361, 363**)
Isocyanid acid (HNCO) in Sgr B2 (**165, 333, 346**);
Formic acid (HCOOH) in Sgr B2 (**405**);
Methanimine (H_2CNH) in Sgr B2 (**129**);
Acetaldehyde (CH_3CHO) in Sgr B2 (**115**);
Formamide ($HCONH_2$) in Sgr A (**139**), Sgr B2 (**281, 139, 291**);
Methylcyanide (CH_3CN) in Sgr B2 (**346**);
Vinilcyanide (H_2CCHCN) in Sgr B2 (**123**);
Methyl acetylene (CH_3C_2H) in Sgr B2 (**333**);
Methyl format ($HCOOCH_3$) in Sgr B2 (**34**);
Dimethyl ether ($(CH_3)_2O$) in Orion nebula (**335**);
Trans-ethyl alcohol (CH_3CH_2OH) in Sgr B2 (**417, 418**).

G. *Unidentified lines*

Some unidentified lines have been observed: U81,5 (**346**); U86,2 (**332, 337**); U89,2 (**37, 253**); U90,7 (**253**); U93,2 (**366**). Possibilities of identification of these lines have been proposed: (**226**); (**226**); (**37, 226, 379**); (**226**); (**147, 366**). See also "Quarterly Summary" on Unidentified Lines.

H. *Candidates for radio observations*

Unsuccessful searches have been made for the following molecules: PN (**253**); nitroxyl HNO (**114**); thioisocyanid acid HNCS (**9**); formil HCO, pyridine C_5H_5N, acroleine CH_2CHCHO (**14**); nitric acid HNO_3, fulven C_6H_6 (**125**); pyridine C_5H_5N, pyrimidine $C_4H_4N_2$ (**320**); benzonitrile C_6H_5CN, benzaldehyde C_7H_6O, toluene $C_6H_5CH_3$, nitrobenzene $C_6H_5NO_2$, cyclobutanone C_4H_6O (**109**). See also the 'Quarterly Summary' I of Negative Searches. The laboratory measurements and calculations of the radio frequencies of H_2D^+ (**258**), HCO^+ (**163**), HNC (**268**), H_2CN^+ (**269**), KOH, KOD (**270**), O_2 (**299**), pyrrol C_4H_5N (**25**), methylenimine (**188**), vinilcyclopropan $C_3H_6CHCH_2$ (**62**) have been reported. Radio intensities of the excited H_2 have been calculated (**293**). Theoretical estimates for the intestellar H_2 and HD rotational lines have been made (**96**). The H_2 formation mechanisms have been discussed (**22, 342**), as well as those for HD (**108, 382**). Abundance data for H_2 estimated from theoretical studies, UV and IR measurements have been reported (**329, 333, 338, 350, 351**). Possibilities of H_2 and N_2 radio observations in molecular complexes H_2-NH_3 and N_2-NH_3 have been discussed (**187**). Radio lines of the molecule of HCl and formation mechanisms of this molecule have been studied (**70, 174**).

I. *Miscellaneous*

General problems related to interstellar masers have been discussed (**97, 130, 131, 132, 133, 211, 290, 343**). Distribution and excitation of molecules in different interstellar objects have been considered (**83, 127, 137, 157, 364, 365, 370, 386**). Molecular formation and destruction processes have been studied (**1, 2, 7, 29, 33, 54, 71, 72, 74, 94, 108, 110, 152, 153, 162, 168, 238, 302, 316, 317, 318, 356, 381, 382, 385**).

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5. EXTRAGALACTIC RADIO ASTRONOMY

(Y. N. Parijskij and S. Pustilnik)

For the last years no major changes have occurred in the development of extragalactic radio astronomy. The main flow of information has been supplied from the high resolution mapping

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of sources of different nature – compact and extended (Cambridge; Westerbork; NRAO, U.S.). These maps have given rise to new concepts on the energy transportation from the nucleus region to the extended components of radio galaxies. A new class of 'tailed' radio galaxies has been discovered, and extremely large objects have been found. There is some progress in the mapping of very compact objects with VLBI techniques, but the general picture of the early stages of evolution of radio events in QSR and RG is not yet clear.

Many new observations of variable radio sources available now, including 408 MHz positive results and short-time scale phenomena up to a fraction of an hour, have been obtained. Permanent interest is taken in BL Lac-type objects. The general trend in this field is a rapidly increasing cooperation between different observatories and between different domains of the e.m. spectrum.

Much progress in the accuracy of position measurement is evident; the radio position now can be certainly more accurate than the optical one. New attempts are being made now to achieve an accuracy adequate to optical identifications of a great number of radio sources. Some new accurate observations of the anisotropy of the Black Body radiation are available, but they are not at the level of the extreme predictions of the Big Bang cosmology as yet. The number of the catalogued sources increases rapidly, approaching that in optical catalogues. Some very deep surveys have been made and new short wavelength surveys are in progress. References to all the subjects mentioned above can be found below.

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Small remarks available in some sections; frequency is given in GHz and flux density in Jy.

1. *Surveys*

	Reference	Freq. min. flux
1.1	Shimmins *et al.* 72*AJP Sup* **23.**	5.0
1.2	Maslowski 72*Act Astr.* **22**, 227.	1.4 0.09
1.3	Pauliny-Toth *et al.* 72*AJ* **77**, 797.	5.0
1.4	Gorshkov *et al.* 72*Izv. Krymsk. Astrofiz. Obs* **45**, 176.	8.6
1.5	Shimmins *et al.* 72*AJP Sup* *26*.	2.7, 0.15
1.6	Colla *et al.* 73*AA Sup* **11**, 291.	
1.7	Davies *et al.* 73*AJPSup28.*	.41, 0.1
1.8	Bolton *et al.* 73*AJPSup30.*	27, 0.22
1.9	Fanti *et al.* 74*AASup* **18**, 147.	.41, 0.5
1.10	Katgert *et al.* 74*AA* **35**, 393.	.61, 1.4, .007
1.11	Sutton *et al.* 74*AJPSup* *33.*	.41, 0.2
1.12	Rinsland *et al.* 74*AJ* **79**, 1129.	1.4, 0.18
1.13	Katgert 75*AA* **38**, 87.	1.4, 0.006
1.14	Bolton *et al.* 75*AJPSup* *34.*	2.7, 0.5
1.15	Bolton *et al.* 75*AJPSup* *34.*	2.7, 0.22
1.16	Wall *et al.* 75*AJPSup34.*	2.7, 0.5
1.17	Shimmins *et al.* 75*AJPSup* *34.*	2.7, 0.5
1.18	Pearson 75*MN* **171**, 475.	0.14, 1.4, 0.009

2. *Flux Density Measurements*

(i) *Optically selected sources: Detections and measurements*

	Reference	Object; Freqs.
2.1	Tovmassian 72*AJ* **77**, 705.	Markarian Gal. 30
2.2	Katgert *et al.* 73*AA* **23**, 171.	QSO's 1.4
2.3	Allen *et al.* 73*AA* **25**, 187.	Gal 1.4
2.4	McCutcheon 73*AJ* **78**, 18.	Gal 6.6
2.5	Berkhuijsen *et al.* 73*AL* **13**, 169.	M31 2.7
2.6	Slee 72*PASA* **2**, 159.	Gal
2.7	Ekers *et al.* 73*AA* **24**, 247.	E Gal 5.0
2.8	Wright *et al.* 72*CIAL* **17**, 585.	Interacting Gal 6.5, 14
2.9	Sulentic *et al.* 73*ApJ* **182**, L17.	Chains, Groups
2.10	Thomasson *et al.* 73*MN* **162**, 295.	Mark. Gal .41
2.11	Peckham 73*NatPS* **246**, 54.	Cyg A
2.12	Gnibert 73*AA* **29**, 335.	M31 companions 1.4
2.13	Tovmassian *et al.* 73*AL* **15**, 97.	Normal 0.43 Spirals
2.14	Tovmassian 73*Astrofiz* **9**, 2.	Clusters of galaxies
2.15	Le Sqrieren *et al.* 74*AA* **31**, 447.	Gal 4.8
2.16	Wright 74*MN* **167**, 273.	Gal 2.7, 5.0

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2.17	Tomasson *et al.* 73 *Radiofizika* **16**, 1342.	Mark. Gal .41
2.18	Israel *et al.* 74*AA* **32**, 363.	M33 H II-regions 1.4
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2.20	Owen 74*AJ* **79**, 427.	Abell Clusters 1.4
2.21	Kellermann 74*ApJ* **194**, L135.	Cen A
2.22	Efanov *et al.* 74*Soviet Astron.* **18**, 4.	3C273 78
2.23	Kaftan-Kassim *et al.* 74*AA* **33**, 343.	Stephan Quintet 0.32, 0.43, 0.61
2.24	Kaufman *et al.* 74*MN* **169**, 15 P	NGC5128 22
2.25	Hitchmeier *et al.* 74*AL* **15**, 209.	3Zw2 16, 2.7, 5, 8.9, 9.9
2.26	Tovmassian *et al.* 74*PASP* **86**, 649.	Mrk galaxies .43
2.27	Guthrie 74*MN* **168**, 15.	Brightest galaxies in Clusters 1.4
2.28	Gerhart 74*Nat* **249**, 743.	OH471 80Q172 0.017-85
2.29	Colla *et al.* 75*AASup* **20**, 1.	Gal 0.41, 1.4, 5.0
2.30	Kaufmann *et al.* 75*ASS* **32**, L25.	Sersic galaxies 22
2.31	Heeschen *et al.* 75*ApJ* **196**, 347.	E-galaxies 31, 86
2.32	Owen 75*AJ* **80**, 263.	Abell Clusters 2.7

(ii) *Other flux density measurements*

		Freq.
2.33	Lipovka 72*Soviet Astron.* **16**, 5.	7.7
2.34	Conklin *et al.* 72*ApJ* **177**, 303.	0.6-85
2.35	Zabolotny *et al.* 72*Soviet Astron.* **16**, 5.	
2.36	Webber 72*AJ* **77**, 625.	0.75, 1.4, 2.7,
2.37	Wall 72*AJPSup* *24*, 1.	47, 64, 1.4, 50
2.38	Schillizzi *et al.* 72*AJP* **25**, 545.	08, 41, 5.0
2.39	Tovmassian *et al.* 72*Astron Tsirk.* *715*.	
2.40	McGee *et al.* 72*AJP* **25**, 581.	5.0
2.41	McGee *et al.* 72*AJP* **25**, 613.	2.7
2.42	Stull *et al.* 73*ApJ* **13**, 73.	8.0
2.43	Shimmnins *et al.* 73*AJP* **26**, 93.	8.9
2.44	Slec *et al.* 73*AJPSup* **27**.	0.08
2.45	Stull 73*AJ* **78**, 285.	0.43
2.46	Finlay *et al.* 73*AJP* **26**, 389.	0.03
2.47	Welch *et al.* 73*PASP* **85**, 456.	22
2.48	Andrew *et al.* 73*ApJ* **185**, 137.	61-11
2.49	Lipovka 73*Astrofiz.Issled. Izv SAO* **5**, 30.	7.7
2.50	Kellermann *et al.* 73*AJ* **78**, 828.	11
2.51	Roger *et al.* 73*AJ* **78**, 1030.	0.01, 0.022
2.52	Bogod *et al.* 73*Radiofizika* **16**, 765.	15
2.53	Crovisier *et al.* 74*AA* **34**, 285.	4.8
2.54	Pauliny-Toth *et al.* 74*AA* **35**, 421.	2.7, 11
2.55	Soboleva 74*Astron. Tsirk* *826*, 1.	7.7
2.56	Bridle *et al.* 74*AJ* **79**, 1000.	1.4
2.57	Condon *et al.* 74*AJ* **79**, 1220.	32
2.58	Dent *et al.* 74*AJ* **79**, 1232.	15
2.59	Maslowski 74*AA* **36**, 395.	2.7
2.60	Rather 74*PASP* **86**, 601.	210
2.61	Grueff *et al.* 75*AASup* **19**, 117.	50
2.62	Efanov *et al.* 74*Astron. Tsirk* *842*, 1.	22
2.63	Fanti *et al.* 75*AASup* *19*, 143.	5.0
2.64	Cogdell *et al.* 75*ApJ* **196**, 363.	140
2.65	Colla 75*AA* **38**, 209.	1.4, 5.0
2.66	Bolton *et al.* 75*AJPSup* *34*,	2.7, 5.0
2.67	Bolton *et al.* 75*AJPSup* **34**.	2.7, 5.0
2.68	Wall *et al.* 75*AJPSup* **34**.	2.7, 5.0
2.69	Shimmins *et al.* 75*AJPSup* **34**.	2.7, 5.0
2.70	Sharp *et al.* 75*AJ* **80**, 335.	0.36
2.71	Clegg *et al.* 74*Nat* **249**, 530.	250
2.72	Zabolotnyj *et al.* 75*Pisma AZh* **1**, 14.	110
2.73	Slee *et al.* 75*AJPSup* **36**.	0.08
2.74	Rowan-Robinson *et al.* 75*MN* **172**, 603.	190
2.75	Efanov *et al.* 75*Izv. Kryms. Astrofiz Obs.* **53**, 144.	77

(iii) *Flux density scales and absolute measurements*

2.76 Dent 72*ApJ* **177**, 93.
2.77 Wills 73*ApJ* **180**, 335.
2.78 Janssen *et al.* 74*AA* **33**, 373.
2.79 Ross *et al.* 75*MN* **170**, 115.

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2.80	Viner 75*AJ*80, 83.	
2.81	Sramek *et al.* 75*ApJ*196, 339.	Mark.Gal 5.0
2.82	Jaffe *et al.* 75*AASup*21, 137.	Abell Clusters 1.4

3. *Position Measurements*

(i) *Better than 1"*

3.1	Douglas *et al.* 73*AJ*78, 1.	Texas
3.2	Crowther 73*Nat*243, 25.	
3.3	Brosche *et al.* 73*ApJ*183, 805.	NRAO
3.4	Ghigo *et al.* 73*AJ*78, 848.	Texas
3.5	Rogers *et al.* 73*ApJ*186, 801.	
3.6	Adgie 74*AJ*79, 846.	RRE
3.7	Grueff *et al.* 75*AASup*19, 117.	B2
3.8	Fanti *et al.* 75*AASup*19, 143.	B2
3.9	Warner *et al.* 75*PASP*87, 103.	

(ii) *Better than 5"*

3.10	Hoskins *et al.* 72*AJP*25, 559.	Molonglo
3.11	Sharp 75*AJ*80, 335.	Texas
3.12	Haynes *et al.* 75*AJ*80, 673.	NRAO

(iii) *Position comparisons*

		Note
3.13	Argue *et al.* 73*AL*14, 99.	opt/radio
3.14	Véron *et al.* 75*AA*42, 1.	opt/radio

4. *Brightness Distribution Measurements*

(i) *Pencil Beam*

4.1	Durdin *et al.* 72*AJ*77, 637.	M31
4.2	Broten 72*AJP*25, 599.	Large Magellanic cloud
4.3	Wright 74*MN* 167, 251.	Interacting Galaxies
4.4	Kaftan-Kassim *et al.* 74*AA* 33, 343.	Stephan Quintet Region
4.5	Berkhuijsen *et al.* 74*AA* 34, 173.	M31
4.6	Baker *et al.* 74*Nat*252, 552.	DA240
4.7	Owen 75*AJ*80, 263.	Abell Clusters
4.8	Dennison *et al.* 75*PASP*87, 83.	M31, M33
4.9	Kap-herr *et al.* 75*AA*41, 115.	M81

(ii) *Interferometric: Baselines < 3 km*

4.10	Van der Kruit *et al.* 72*AA*21, 169.	NGC4258
4.11	Yip *et al.* 72*ApJ*177, 291.	Cyg A
4.12	Riley 73*MN*161, 167.	3C
4.13	Baldwin *et al.* 73*MN*161, 127.	NGC
4.14	Becker *et al.* 73*NatPS*244, 138.	2048 + 31
4.15	Harris 73*MN*163, 19.	3C52, 3C192.
4.16	Miley 73*AA*26, 413.	3C
4.17	Wellington *et al.* 73*Nat* 244, 502.	NGC1265
4.18	Arp 73*ApJ*183, 791.	Spiral galaxies
4.19	Miley *et al.* 73*AA*28, 359.	3C
4.20	Burke *et al.* 73*AA*28, 379.	Interacting galaxies
4.21	Van der Kruit 73*AA*29, 231.	Bright spirals
4.22	Van der Kruit 73*AA*29, 249.	Bright spirals
4.23	Donivom *et al.* 74*ApJ* 187, 11.	Clusters of galaxies
4.24	Slingo 74*MN*168, 307.	3C
4.25	Högbom *et al.* 74*AA*34, 341.	
4.26	Schwarz *et al.* 74*AJP*27, 563.	PKS
4.27	de Bruyn *et al.* 74*AA*33, 351.	Seyfert galaxies nuclei
4.28	Sramek *et al.* 74*ApJ*191, 633.	Mrk 6
4.29	Wilkinson 74*Nat*252, 661.	M87 jet
4.30	Kaufmann *et al.* 74*MN* 169, 15.	Cen A
4.31	Riley 75*MN*170, 53.	4C
4.32	Colla *et al.* 75*AASup*20, 1.	Gal
4.33	Fanti *et al.* 75*AASup*19, 143.	B2QSOs
4.34	Kaftan-Kassim *et al.* 75 *Nat*253, 176.	Stephan Quintet
4.35	Colla *et al.* 75*AA*38, 209.	B2
4.36	Schillzzi *et al.* 75*AA*40, 221.	NGC7385
4.37	Jaffe *et al.* 75*AASup*21, 137.	Abell Clusters
4.38	Haynes *et al.* 75*AJ*80, 673.	Normal galaxies
4.39	Stull *et al.* 75*AJ*80, 559.	3C
4.40	Israel *et al.* 75*AA*40, 421.	M101
4.41	Schilizzi 75*MRAS*79, 1.	

(iii) *Interferometric: Baselines > 3 km*

4.42	Clark *et al.* 72*AZh*16, 4.	
4.43	Erickson *et al.* 72*ApJ*177, 101.	

4.44 Peckman *et al.* 72*NatPS*240, 76.
4.45 Critchley *et al.* 72*MN*160, 271.
4.46 Wraith 72*MN*160, 283.
4.47 Wilkinson 72*MN*160, 305.
4.48 Purton *et al.* 72*MN*159, 15.
4.49 Browne *et al.* 73*Nat* 244, 19.
4.50 Clark *et al.* 73*ApJ*182, L57.
4.51 Legg *et al.* 73*Nat*244, 18.
4.52 Riley *et al.* 73*MN*164, 271.
4.53 Matveenko *et al.* 73*Soviet Astron.*17, 6.
4.54 Shapiro *et al.* 73*ApJ*183, L47.
4.55 Kellermann *et al.* 73*ApJ*183, L51.
4.56 Northover 73*MN*165, 369.
4.57 Willis *et al.* 74*Nat*250, 625.
4.58 Wilkinson *et al.* 74*MN*168, 515.
4.59 Rogers *et al.* 74*ApJ*193, 293.
4.60 Pooley *et al.* 74*MN*169, 477.
4.61 Bash *et al.* 74*AJ*79, 1341.
4.62 Hargrave 74*MN*168, 491.
4.63 Turland 75*MN*170, 281.
4.64 Wittels *et al.* 75*ApJ*196, 13.
4.65 Turland 75*MN*172, 181.
4.66 Cotton *et al.* 75*AJ*80, 353.
4.67 Rellarmann *et al.* 75*ApJ*197, L113.
4.68 Niell *et al.* 75*ApJ*197, L109.
4.69 Fomalont *et al.* 75*Nat*257, 99.
4.70 Spinrad *et al.* 75*ApJ*198, 7.

(iv) *Occultation*

4.71 Abramyan 72*Soviet Astron.*16, 4.
4.72 Kapahi *et al.* 73*AL*14, 31.
4.73 Kapahi *et al.* 73*AJ*78, 673, 805.
4.74 Joshi *et al.* 73*AJ*78, 1023, 1141.

(v) *Scintillation*

4.75 Shishov 72*Soviet Astron.*16, 6.
4.76 Harris 73*AJ*78, 369.
4.77 Shishov 72*IVUZR*15, 1277.
4.78 Vitkevich *et al.* 72*Trudy Fiz. Inst. Akad. Nauk SSSR*62, 42.
4.79 Hewish *et al.* 74*Nat*252, 657.
4.80 Harris 74*AJ*79, 1211.
4.81 Cohen *et al.* 74*ApJ*192, 193.
4.82 Condon *et al.* 75*ApJ*197, 31.

5. *Polarization Measurements*

(i) *Integral linear polarization*

		Freq.
5.0	Berge *et al.* 72*AJ*77, 810.	1.4, 1.6, 5.0
5.1	Gauss *et al.* 73*ApJ*179, 439.	1.25–1.45
5.2	Efimov *et al.* 72*Izv. Krymsk Agtrofiz. Obs.*46, 3.	Opt
5.3	Strom 73*AA*25, 303.	0.6
5.4	Bignell *et al.* 73*AJ*78, 536.	6.7, 11
5.5	Bignell 73*AJ*78, 557.	6.7, 11
5.6	Wardle *et al.* 74*ApJ*189, 399.	2.7, 8.1
5.7	Conway *et al.* 74*MN*168, 137.	41–14
5.8	Haves *et al.* 74*MN*169, 117.	97
5.9	Vallée *et al.* 74*ApJ*193, 303.	66, 14
5.10	Wardle *et al.* 74*ApJ*194, 249.	2.7, 8.1
5.11	Scielstad *et al.* 75*AJ*80, 271.	5
5.12	Ekers *et al.* 75*AA*38, 67.	1.4
5.13	Gardner *et al.* 75*AJP35.*	1.4, 1.7, 2,7, 5.0

(ii) *Linear polarization distribution*

5.14 Fomalont 72*AL*12, 187.
5.15 Yip *et al.* 72*ApJ*177, 291.
5.16 Kronberd *et al.* 73*AL*14, 25.
5.17 Mirovsky *et al.* 73*AZh*17, 5.
5.18 Miley 73*AA*26, 413.
5.19 Miley *et al.* 73*AA*28, 359.
5.20 Högbom *et al.* 74*AA*34, 341.
5.21 Soboleva 74*Soviet Astron*18, 6.
5.22 Baker *et al.* 74*Nat*252, 552.
5.23 Schwarz *et al.* 74*AJP*27, 563.
5.24 Stull *et al.* 75*AJ*80, 559.

(iii) *Circular polarization*

5.25 Seaquist 73*AA*22, 299.
5.26 Seaquist *et al.* 73*NatPS*242, 20.
5.27 Seaquist *et al.* 74*AJ*79, 918.
5.28 Ekers 75*AA*38, 67.
5.29 Roberts *et al.* 75*AJP*28, 325.

6. *Variable Source Observations*

		Freq.
6.1	Romano 72*Mem. Soc. Astron. Italiana. Nuova Ser.*43, 309.	Opt
6.2	Gorshkov *et al.* 72*Soviet Astron.*16, 4.	6.7, 8.0, 11
6.3	Tsesevich 72*Astron. Tsirk. 688*, 7.	Opt
6.4	Babadzhanjanz *et al.* 72 *Astron. Tsirk 701*, 1.	Opt
6.5	Medd *et al.* 72*MRAS*77, 109.	6.7, 11
6.6	Hunstead 72*AL*12, 193.	.41
6.7	Haden-thorn 72*Astron. Tsirk. 714*, 5.	Opt
6.8	Epstein *et al.* 72*ApJ*178, L51.	Opt, IR, Radio
6.9	Dent *et al.* 72*AJ*77, 819.	7.8
6.10	Lu 72*AJ*77, 829.	Opt
6.11	Efanov *et al.* 72*Izv. Krymsk. Astrofiz. Obs.*45, 172.	36

6.12	Rieke *et al.* 72*ApJ*177, L115.	IR
6.13	Visvanathan 73*ApJ*179, 1.	Opt
6.14	Craine *et al.* 73*ApJ*179, L53.	Opt
6.15	Visvanathan *et al.* 73*ApJ*179, 721.	Opt
6.16	Weistrop 73*NatPS*241, 157, **243**, 144.	Opt
6.17	Godsmith *et al.* 73*ApJ* **180**, 661.	Opt
6.18	De Yound *et al.* 73*ApJ* **180**, L61.	2.7, 8.1
6.19	Dent *et al.* 73*AJ*78, 163.	31
6.20	Pfau 73*Inform. Bull. Variable Stars* 787.	Opt
6.21	Angione 73*AJ*78, 353.	Opt
6.22	Babadzhanyants *et al.* 73 *Trudy Astron. Obs. Leningrad*29, 72.	Opt
6.23	Kellermann *et al.* 73*ApJ* **179**, L141.	7.9
6.24	Epstein 73*IAU Circ.***2519**.	
6.25	Bignell 73*AJ*78, 557.	6.6, 11
6.26	Bignell 73*AJ*78, 557.	6.6, 11
6.27	Eggen 73*ApJ*186, L1.	Opt
6.28	Shapiro *et al.* 73*ApJ*183, L47.	7.8
6.29	Kellermann *et al.* 73*ApJ* **183**, L51.	
6.30	Babadzhanyants *et al.* 74 *Trudy Astron. Obs. Leningrad*30, 69.	Opt
6.31	Crovisier *et al.* 74*AA*30, 175.	Opt B20912 + 29
6.32	Tabara *et al.* 74*Tokyo Astron. Bull. 2nd Ser.***228**, 2633.	Opt
6.33	Riplinger 74*ApJ*191, L109.	Opt
6.34	Haves *et al.* 74*MN*169, 117.	.97
6.35	Seielstad 74*ApJ*193, 55.	
6.36	Bramdie *et al.* 74*Nat*252, 212.	2.7
6.37	Usher *et al.* 74*Nat*252, 365.	Opt PKSOO48 −097
6.38	Dent *et al.* 74*AJ*79, 1232.	15
6.39	Miller *et al.* 74*AJ*79, 1352.	Opt PKS1514 −24
6.40	Malumyan *et al.* 74 *Astrofiz*10, 4.	.41 3C454.3
6.41	Sramek *et al.* 74*ApJ*101, L13.	2.7, 5, 8Mrk 348
6.42	Fogarty *et al.* 74*ApJ*191, 305.	90 NGC 1068
6.43	Hitchmeier *et al.*74*ApJ* **15**, 209.	5, 8, 9, 9.9 3Zw2
6.44	Andrew *et al.* 74*ApJ*191, 51.	Opt Radio Bllac
6.45	Frohlich *et al.* 74*MN*168, 417.	Opt OJ287
6.46	Milone 74*PASP*86, 899.	Opt Bllac
6.47	Selmes *et al.* 75*MN*170, 15.	Opt
6.48	Brandie *et al.* 74*Nat*252, 212.	2.7
6.49	Adgie *et al.* 75*MN*170, 31.	1, 2.7, 8.0
6.50	Markava *et al.* 74*Astron. Tsirk843*, 1.	Opt
6.51	Kurochkin 74*Astron. Tsirk. 844*, 1.	Opt
6.52	Seielstad *et al.* 75*AJ*80, 271.	5.0
6.53	Sanamyan *et al.* 75*Astrofiz* **11**, 1.	0.32
6.54	Sanamyan *et al.* 75*Astrofiz***11**, 1.	0.41
6.55	Markova 75*Astron. Tsirk. 862*, 1.	Opt
6.56	Markova 75*Astron. Tsirk. 856*, 4.	Opt
6.57	Onrassine 75*Nat*254, 125.	Opt
6.58	Saakyan 75*Astron. Tsirk. 861*, 7.	Opt
6.59	Fogarty *et al.* 75*Nat*254, 124.	22
6.60	Ekers *et al.* 75*AA*38, 67.	1.4
6.61	Price *et al.* 75*Nat*255,467.	10.7
6.62	Craine *et al.* 75*PASP*87, 123.	Opt
6.63	Smith *et al.* 75*PASP*87, 149.	Opt
6.64	Riplinger 75*AJ*80, 669.	Opt
6.65	Veron *et al.* 75*AA*39, 281.	Opt
6.66	Veron 75*AA*41, 423.	Opt
6.67	Dowison 75*ApJ*196, L133.	Opt
6.68	Litter *et al.* 75*ApJ*199, L133.	Opt
6.69	Winkler *et al.* 75*ApJ*199, L139.	X-ray
6.70	Stamard *et al.* 75*Nat*255, 384.	0.41, 0.96

7. Microwave Background Measurements

7.1 Parijskij 72*Soviet Astron.* **16**, 6.
7.2 Hegyi *et al.* 73*BAAS*5, 34.
7.3 Boynton *et al.* 73*ApJ*181, 243.
7.4 Carpenter *et al.* 73*ApJ*182, L61.
7.5 Muehlner *et al.* 73*Phys. Rev.***D7**, 326.
7.6 Bahcall *et al.* 73*ApJ*182, L95.
7.7 Parijskij 73*ApJ* **180**, L47.
7.8 Parijskij 73*Soviet Astron.***17**, 3.
7.9 Antonov 73*IVUZR*16, 759.

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7.10 Stankevich 74*Soviet Astron.* **18**, 1.
7.11 Boynton *et al.* 74*Nat***247**, 528.
7.12 Gush 74*Can.J.Phys.* **52**, 554.
7.13 Robson *et al.* 74*Nat***251**, 591.
7.14 Blair 74*IAU Symp.* **63**, 143.
7.15 Partridge 74*IAUSymp.* **63**, 143.
7.16 Boynton 74*IAUSymp.* **63**, 163.
7.17 Rozental 74*Novye probl.astrofiz. Trudi Mosk. Univ.* **91**, 11.
7.18 Hegyi *et al.* 74*ApJ***190**, 543.
7.19 Mather *et al.* 74*IEEE Microwave Theory Techn.* **22**, 12, Part 1, 1046.
7.20 Wall *et al.* 75*MN***171**, 9.
7.21 Woody *et al.* 75*PRL***34**, 1036.

8. *Miscellaneous Observations*

8.1	Rieke 72*ApJ***176**, L61.	IR of BL Lac-type
8.2	Carswell *et al.* 73*Nat***242**, 394.	OH 471
8.3	Wampler *et al.* 73*Nat***243**, 336.	OO172
8.4	Wrich 73*AL***13**, 89.	B2 1101 + 38
8.5	Tritton *et al.* 73*MN***162**, 31.	4C 31.63
8.6	Becklin *et al.* 73*ApJ***181**, L27.	NGC253
8.7	Sargent 73*ApJ***182**, L13.	Redshifts of 4C sources
8.8	Babadzhanjants *et al.* 72 *Astrofiz***8**, 4.	SyG variability
8.9	Baldwin *et al.* 73*ApJ***185**, 739.	QSO candidates
8.10	Wampler *et al.* 73*Nat***246**, 203.	Double QSO
8.11	Riruchi *et al.* 73*PASJ***25**, 555.	OJ287 optic 8 radio
8.12	Pronik 74*Soviet Astron.* **18**, 3.	NGC1275
8.13	Argue *et al.* 74*MN***168**, 1.	4C 11.50
8.14	Schmidt 74*ApJ***193**, 505.	Redshifts of 4C QSSs
8.15	Schmidt 74*ApJ***193**, 509.	Spectroscopy of faint blue objects
8.16	Baldwin *et al.* 74*ApJ***193**, 513.	Optical lines of OQ172
8.17	Stockton 74*Nat***250**, 308.	Galaxy near 4C 11.50
8.18	Burke *et al.* 74*AA***34**, 445.	Excess redshifts
8.19	Penston *et al.* 74*MN***169**, 357.	Seyfert galaxies
8.20	Teerikorpi 74*Nat***252**, 110.	Redchifts of Markarian galaxies
8.21	Kinman *et al.* 74*ApJ***194**, L1.	Optical 8 IR M87 jet
8.22	Pronik 74*Soviet Astron.* **18**, 6.	Nucleus of NGC1275
8.23	Andrews *et al.* 74*MN***168**, 7.	Multicolour photometry APLib PKS 0521-36
8.24	Disney *et al.* 74*ApJ***194**, L79.	Redshift nature of AP Lib
8.25	Strittmatter 74*ApJ***190**, 509.	Spectroscopy of identified radio-sources
8.26	Oke 74*ApJ***189**, L47.	Spectrophotometry of OQ 172 SO11471
8.27	Schönfelder *et al.* 74*ApJ* **191**, L1	γ - ray Back-ground
8.28	Denisyuk *et al.* 74*Astron. Tsirk. 837*, 1.	Mark 380
8.29	Baldwin 75*ApJ***195**, L55.	Opt.spectrum BL Lac
8.30	Carsuell *et al.* 75*ApJ***195**, 269.	Optical lines of OH 471.
8.31	Osterbrock *et al.* 75*ApJ* **197**, L41.	Broad lines in radio galaxies
8.32	Grindlau *et al.* 75*ApJ* **197**, L9.	γ - rays from Cen A
8.33	Baldwin 75*ApJ***196**, L91.	Optical lines in 3C 273 S 0736 + 01
8.34	Grewing *et al.* 75*AA***42**, 119.	Pair NGC3067/ 3C232 21 cm absorption
8.35	Osterbrock *et al.* 75*ApJ* **197**, 535.	Emission-Line Spectrum of Cyg A
8.36	Grindlay *et al.* 75*ApJ***197**, L41.	Broad Balmer Lines in Radio-galaxies
8.37	Kinman 75*ApJ***197**, L49.	Nebulosity in BL Lac
8.38	Tung Chan 75*ApJ***198**, 45.	Emission Line strengths in QSOs
8.39	Grindley *et al.* 75*ApJ***197**, L9.	γ-rays from Cen A
8.40	Margon *et al.* 75*ApJ***197**, 25.	X-ray spectroscopy Extragalactic radiosources
8.41	Boksenberg *et al.* 75*MN* **172**, 289.	Spectroscopy of 3C273.
8.42	Morgan *et al.* 75*MN***171**, 599.	Ultraviolet colours of quasars

9. *Optical Identifications*

9.1 Véron 72*AA***20**, 471.
9.2 Merkelijn 72*AJP***25**, 451.
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9.4 Argue *et al.* 72*MN***160**, 197.
9.5 Tritton 72*MN***158**, 277.
9.6 Spinrad *et al.* 73*ApJ***179**, L71.
9.7 Glass 73*MN***162**, 35.
9.8 Bergamini *et al.* 73*AA***23**, 195.
9.9 Gent *et al.* 73*Nat***241**, 261.
9.10 Argue *et al.* 73*NatPS***241**, 139.
9.11 Peterson *et al.* 73*AL***13**, 187.
9.12 Parkes *et al.* 73*MN***162**, 117.
9.13 Agnew *et al.* 73*PASP***85**, 162.
9.14 Fanti *et al.* 73*AA***24**, 69.
9.15 Browne *et al.* 73*Nat***244**, 146.
9.16 Pauliny-Toth *et al.* 73*AA***27**, 475.
9.17 Véron *et al.* 73*AL***14**, 237.
9.18 Welch *et al.* 73*PASP***85**, 456.
9.19 Wills *et al.* 73*AJ***78**, 521.
9.20 Véron *et al.* 73*AA***28**, 319.
9.21 Wampler *et al.* 73*Nat***246**, 203.
9.22 Carswell *et al.* 73*Nat***246**, 89.
9.23 Tritton *et al.* 73*MN***165**, 245.
9.24 Tritton *et al.* 73*MN***165**, 253.
9.25 Baldwin *et al.* 73*MN***165**, 259.
9.26 Bolton *et al.* 73*AJPSup30.*
9.27 Wall 73*AL***15**, 101.
9.28 Joshi *et al.* 73*AJ***78**, 1023, 1141.
9.29 Kristian *et al.* 74*ApJ***191**, 43.
9.30 Peterson *et al.* 73*AL***15**, 109.
9.31 Faranoff *et al.* 73*AL***15**, 117.
9.32 Brandie *et al.* 74*AJ***79**, 903.
9.33 Katgert *et al.* 74*AA***35**, 393.
9.34 Grueff *et al.* 74*AA***35**, 491.
9.35 Johnson 74*AJ***79**, 1006, 1123.
9.36 Wills *et al.* 74*ApJ***190**, L97.
9.37 Longair *et al.* 75*MN***170**, 121.
9.38 Adgie *et al.* 75*MN***170**, 31.
9.39 Colla *et al.* 75*AASup***20**, 1.
9.40 Richter 75*AN***296**, 65.
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9.42 Bystedt 75*AA***39**, 155.
9.43 Colla 75*AA***38**, 209.
9.44 Bolton *et al.* 75*AJPSup34.*
9.45 Shinmins *et al.* 75*AJPSup34.*
9.46 Warner *et al.* 75*PASP***87**, 103.
9.47 Vidal 75*AA***42**, 145.
9.48 Lelievre *et al.* 75*AA***42**, 293.
9.49 Notni *et al.* 75*AN***296**, 197.
9.50 Spinrad *et al.* 75*ApJ***198**, 7.
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10. *Interpretation of Spectral Data*

10.1 Gnedin *et al.* 72*Pisma Zh.Exp.Teor.Fiz.* **16**, 45. — Non-exponential radio spectra
10.2 Wall 72*AJPSup***24**, 49. — Statistical analysis
10.3 McGee *et al.* 72*AJP***25**, 619. — Sources of Large Magellanic Cloud
10.4 Kurilchik 73*Soviet Astron.* **17**, 1. — Haloes of double radiosources
10.5 Faranoff *et al.* 73*MN***161**, 393. — Evolution of sources
10.6 Braude *et al.* 73*ASS***20**, 59. — Non-linear low-frequency spectra
10.7 Grueff *et al.* 72*Lab.Radio-astron.CNR, Ist.Fis. Bologna, Separate Print.* — Correl.spectral index-optical power
10.8 Slingo 74*MN***168**, 307. — Radio sources with very steep spectra
10.9 Jones *et al.* 74*Nat***250**, 472. — Structure of OH471 8 OQ172
10.10 Brandie *et al.* 74*AJ***79**, 903. — 'Two-color' radio analogue
10.11 Braude 74*ASS***31**, 203. — Effects of distribution function of relativistic particles
10.12 Condon *et al.* 74*AL***15**, 203. — Non-uniform compact sources

11. *Interpretation of Variability Data/Compact Sources*

11.1 Dorschner *et al.* 72*AN***294**, 65. — Model
11.2 Budden *et al.* 72*Proc.Roy. Soc.London, SerA.* **330**, 65. — Scintillation of extended Sources
11.3 Alvarez *et al.* 73*ApJ***179**, 391. — 3C 279
11.4 Nicolson 73*NatPS***241**, 90. — Variable sources, non-variable sources.
11.5 Chertoprud *et al.* 73*NatPS* **242**, 70. — 3C273 Cyclicity
11.6 Chertoprud *et al.* 73*ApJ* **182**, L53. — 3C273 Independent Pulses
11.7 Jones *et al.* 73*ApJ***186**, 791. — Decimetric flux variations
11.8 Ginzburg 73*Nat***246**, 415. — Intergalactic gas and flares
11.9 Babadzanyants *et al.* 74 *Astron.Tsirk. 817*, 3. — Periodicity in 3C 371.
11.10 Jones 74*ApJ***191**, L15. — Angular radius of PKS 0735 + 178
11.11 Elliot *et al.* 74*ApJ***192**, L3. — Accreting black hole model
11.12 Cocke *et al.* 75*ApJ***195**, 279. — Low-frequency variability

12. *Interpretation of Structure Data*

12.1 Allen *et al.* 73*Nat***241**, 260. — Interacting galaxies
12.2 Guthrie 73*ASS***23**, 391. — Extragalaetic X-ray sources
12.3 Van der Kruit 73*AA***29**, 263. — Bright spiral galaxies
12.4 Vorontson-Velyaminov 74 *Astron.Tsirk. 816*, 1. — Comet-like galaxies

12.5	Browne *et al.* 74*Nat*252, 209.	High redshift QSOs
12.6	Turland 75*MN*170, 281.	M87
12.7	Aizu 75*Progr. Theor. Phys.* 53, 893.	Extended sources in clusters of gal.

13. *Interpretation of Polarization Data*

13.1	Mitton 73*ApJ*13, 19.	Internal Faraday rotation
13.2	Melrose 72*PASA*2, 140.	Self-absorbed synchrotron sources
13.3	Fukui 73*PASJ*25, 181.	Internal Faraday rotation
13.4	Sazonov 72*ASS*19, 3, 25.	Circular polarization synchrotron source
13.5	Pacholczyk 73*MN*163, 29P.	Circular repolarization
13.6	Nelson 73*PASJ*25, 489.	Rotation measure-redshift
13.7	Bignell 73*AJ*78, 1058.	Rotation measure-circular polarization
13.8	Conway *et al.* 74*MN*168, 137.	Polarization vs wavelength
13.9	Tokarev 74*Radiofizika*16, 1789.	Faraday depolarization
13.10	Pacholczyk *et al.* 74*ApJ* 192, 591.	Absorption effects on circular repolarization
13.11	Pacholczyk 75*ApJ*196, 125.	Oscillatory behaviour of intensity
13.12	Kolobov *et al.* 75*Soviet Astron.* 19, 169.	Degree of homogeneity of magnetic field
13.13	Stocke *et al.* 75*MN*172, 567.	Synchrotron emission in plasma

14. *Redshift Dependent Properties of Sources*

14.1	Richter 73*ApJ*13, 63.	Ang. size
14.2	Bahcall *et al.* 73*ApJ*179, 699.	Hubble diagram QSO
14.3	Rowan-Robinson 73*AA* 23, 331.	Two classes of quasars
14.4	·Ross 73*AA*24, 471.	Redshift/Variation particle rest mass
14.5	Zotov *et al.* 73*MN*162, 127.	QSO Luminosity evolution
14.6	Chiu *et al.* 73*ApJ*181, 295.	Two types of quasars
14.7	Dehren *et al.* 73*AL*14, 91.	Quasar peculiar velocities
14.8	Jackson 73*MN*162, 11.	Redshift-angular size
14.9	Nelson 73*PASJ*25, 489.	Redshift-rotation measure
14.10	Evans 74*ASS*30, 299.	Distance of BL Lac
14.11	Oke *et al.* 74*ApJ*189, L5.	Distance of BL Lac
14.12	Baldwin *et al.* 75*ApJ* 195, L55.	Distance of BL Lac
14.13	Thuan *et al.* 75*ApJ*201, 45.	Distance of BL Lac

15. *Miscellaneous Correlations*

15.1	Thiel 72*ASS*17, 39.	Double Source Orientation
15.2	Lyutyi 72*Soviet Astron.* 16, 5.	Optical/Radio Variability
15.3	Ozernoy 72*Soviet Astron.* 16, 6.	Pairs Galaxy QSO
15.4	Oemler *et al.* 72*ApJ*176, L47.	QSO in cluster of Calaxies
15.5	Kristian 73*ApJ*179, L61.	QSO nuclei of Galaxies
15.6	Evans 73*NatPS*241, 5.	Ionization potential redshift
15.7	Andrew *et al.* 73*NatPS* 241, 158.	Chain of radio sources
15.8	Strom 73*NatPS*244, 2.	Depolarization/Size
15.9	Burbidge *et al.* 73*ApJ*182, L47.	QSO-galaxies associations
15.10	Grueff *et al.* 73*AASup*11, 41.	Spectral Index-Ratio of Radio to Optical Power
15.11	Browne *et al.* 73*MN*162, 21P.	QSO' s/bright galaxies
15.12	Miller *et al.* 73*ApJ*179, L83.	BSO/galaxies
15.13	Hall *et al.* 73*NatPS*241, 31.	Optical Amplitudes-Radio Spectra
15.14	Bogart *et al.* 73*ApJ*181, 609.	Clustering among clusters of galaxies and quasars
15.15	Morris *et al.* 73*PASJ*25, 295.	Depolarization-Luminosity
15.16	Bahcall *et al.* 73*ApJ*183, 777.	QSO-clusters of galaxies
15.17	Condon *et al.* 73*ApJ*183, L33.	5C spectral indices
15.18	Ames *et al.* 73*ApJ*14, 199.	Variability-luminosity
15.19	Basu 73*Obs*93, 184.	Opt.variability radio spect.index
15.20	Rozyczka 73*Act Astr.* 23, 233.	QSO-galaxies coincidence
15.21	Hazard *et al.* 73*Nat*246, 205.	Discrepant redshifts of QSO
15.22	Baldwin *et al.* 73*MN*165, 259.	X-ray clusters–steep spectra
15.23	Guthrie 74*ASS*27, 489.	X-ray and radio emission by clusters of galaxies.

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15.24	Owen 74*ApJ*189, L55.	Radio and X-ray emission-optical-type correlation
15.25	Tovmassian *et al.* 74 *Astrofiz*10, 1.	Radio emission-outstanding bright galaxy in cluster
15.26	Bell 74*ApJ*194, 245.	Quasar-cluster association
15.27	Noonan 74*ApJ*191, 301.	Frequency of peakpower to peak
15.28	Tovmassian *et al.* 74*Nat* 250, 474.	Radio galaxies in clusters
15.29	Vallee 74*AJ*79, 1015.	Polarization at 6 cm and other parameters
15.30	Ricke *et al.* 74*ApJ*192, L115.	Optical IRbehavior OJ287 Similar objects
15.31	Disney 74*ApJ*193, L103.	BL Lac object in cluster of galaxies
15.32	Evans 74*Obs*94, 50.	Radio magnitude redshift relation
15.33	Mchardy 74*MN*169, 527.	Clusters of galaxies; radio galaxies
15.34	Baldwin 74*Obs*94, 264.	Radiosources in clusters
15.35	Riley 75*MN*170, 53.	Brightest galaxy of cluster-radio-source
15.36	Roeder 75*Nat*255, 124.	Angular diameter -redshift
15.37	Readhead *et al.* 75*MN* 170, 393.	Scintillating radio sources-evolution
15.38	Battistini *et al.* 75*AA*40, 217.	Quasar-group of galaxies
15.39	Swarup 75*MN*172, 501.	Anglular size-flux density
15.40	Dolan 75*ApJ*16, 65.	Probability of associat. of pairs of different distances
15.41	Van den Bergh 75*ApJ* 198, L1.	Quasar cluster association

16. *Interpretation of Microwave Background Data*

16.1 Layser *et al.* 73*ApJ*179, 361.
16.2 Noerdlinger 73*PRL*30, 761.
16.3 Dautcourt 74*AN*295, 123.
16.4 Anile 74*ASS*29, 415.
16.5 Rowan-Robinson 74*MN*168, 45P.
16.6 Doroshkevich *et al.* 74*Soviet Astron.* 18, 5.
16.7 Illarionov *et al.* 74*Soviet Astron.* 18, 6.
16.8 Chan *et al.* 75*ApJ*195, 1.
16.9 Hoyle 75*ApJ*196, 661.
16.10 Schwartz 74*ApJ*194, L139.
16.11 Wall *et al.* 75*MN*171, 9.
16.12 Wesson 75*ASS*36, 363.
16.13 Dehnen *et al.* 75*ASS*36, 473.
16.14 Dubrovioh 75*Pisma AZh*1, 10, 3.
16.15 Wickramasinghe *et al.* 75*ASS*35, L9.

17. *Theory of Radio Sources*

(i) *Radiation Theory*

17.1	Norman *et al.* 73*AA*24, 121.	Turbulent plasma
17.2	Windsor *et al.* 74*ApJ*190, 167.	Inverse plasmon scattering
17.3	Pomraning 74*ApJ*191, 183.	Stokes parameters induced processes
17.4	Glesson *et al.* 74*MN*168, 379.	Synchrotron from truncated power-law energy spectrum
17.5	Blandford 75*MN*170, 551.	Amplification of radiation by relativistic particles
17.6	Blandford *et al.* 75*ASS*36, 303.	Induced Compton Scattering
17.7	Chugunov *et al.* 75*ASS*32, L7.	Curvature radiation

(ii) *Effects of Compton scattering*

17.8	Okoye 72*MN*160, 339.	X-ray emission
17.9	Bonometto *et al.* 73*AL*13, 193.	Circular Polarization
17.10	Albano *et al.* 73*ASS*21, 177.	Synchrotron/ Black-Body.
17.11	Bergeron *et al.* 72*CIAL* 17, 583.	Observational consequences
17.12	Okoye 73*MN*165, 413.	X-ray generation in QSS
17.13	Harris *et al.* 74*ApJ*188, 209.	Magnetic field in clusters of galaxies
17.13a	Cocke *et al.* 75*ApJ*195, 279.	Low-frequency variability
17.13b	Guthrie *et al.* 75*MN*172, 85.	3C273 jet
17.14	Illarionov *et al.* 74*Soviet Astron.* 18, 4.	Formation and evolution of radiation spectra
17.15	Ochelkov *et al.* 74*Soviet Astron.* 18, 6.	Plasmaboilers
17.16	Stewart 75*AA*41, 169.	Strong radiative reaction
17.17	Guthrie *et al.* 75*MN*172, 85.	3C273 jet

(iii) *Source models*

17.18	Ozernoy 72*Soviet Astron.* 16, 5.	QSO magnetoid

17.19	Aizu *et al.* 71*Progr. Theor. Phys. Sup.* **49**, 228.	
17.20	Ozernoy 72*Astron. Tsirk.* *718*, 1, 3.	Nuclei of galaxies magnetoid
17.21	Pacholczyk *et al.* 73*ApJ* **179**, 21.	Restrictions of possible models
17.22	Pecker *et al.* 73*Nat* **240**, 338.	Abnormal redshifts
17.23	Jones 73*AL* **14**, 47.	Sgr A West
17.24	Mashhoon 73*ApJ* **181**, L65.	Absorption redshifts
17.25	Cohen 73*ApJ* **181**, 619.	Absorption lines
17.26	Jura 73*ApJ* **181**, 627.	3C273 helium abundance
17.27	Ptak *et al.* 73*Nat* **243**, 280.	Radially streaming proton model
17.28	Dorschner *et al.* 72*ASS* **19**, 263.	IR spectra
17.29	Clapp 73*Phys. Rev.* **7**, 345.	QSO partially collapsed matter
17.30	Bergeron *et al.* 73*AA* **22**, 385.	IR X-ray luminosity
17.31	Longair *et al.* 73*MN* **164**, 243.	Extended radio sources
17.32	Andrew 73*ApJ* **186**, L3.	Models of BL Lac
17.32a	Rees 75*MN* **171**, 53.	Black holes in radio components
17.32b	Peterson *et al.* 75*ApJ* **195**, 88.	Synchrotron-inverse Compton
17.33	Bridle *et al.* 73*AL* **15**, 21.	Double radio source models
17.34	Peterson *et al.* 73*ApJ* **186**, 421.	Prolonged injection model
17.35	Stepanyan 73*Soviet Astron.* **17**, 6.	Model of galactic center
17.36	Ohnishi 73*ASS* **25**, 217.	Pulsating active nucleus
17.37	Ozernoy 73*Astron. Tsirk.* *804*, 1.	Constraints models
17.38	Jones *et al.* 74*ApJ* **188**, 353.	Canonical nonthermal source
17.39	Jones *et al.* 74*ApJ* **192**, 261.	Compact nonthermal sources
17.40	Buibidge *et al.* 74*ApJ* **193**, 43.	Energetics of compact sources
17.41	Condon *et al.* 74*ApJ* **15**, 203.	Non-uniform compact sources
17.42	Sanders 74*Nat* **248**, 390.	Super light velocities
17.42a	Rees 75*MN* **171**, 1.	Quasar absorption spectra

(iv) *Magnetohydrodynamics source confinement*

17.43	De Young 72*ApJ* **177**, 573.	Relativistically expanding sources
17.44	Ozernoy *et al.* 73*AL* **13**, 209.	Magnetic dipole radiation
17.45	Mackay 73*MN* **162**, 1.	Limits to velocity of separation of components
17.46	De Young *et al.* 73*Comm. Astrophys. Space. Phys.* **5**, 29.	Form of extended sources
17.47	Gull *et al.* 73*Nat* **244**, 80.	Bubble model
17.48	Jaffe *et al.* 73*AA* **26**, 423.	Tailed radio sources gas in clusters of galaxies
17.49	Christiansen 73*MN* **164**, 211.	Multiple explosions
17.50	Okoye 73*MN* **165**, 393.	M87 jet
17.51	Kurilchik 74*Astron. Tsirk.* *806*, 5.	'Tailed' radio galaxies
17.52	Rumyantsev 74*Astrofiz* **10**, 1.	Gaseous ejections in active galaxies
17.53	Blandford *et al.* 74*MN* **169**, 395.	Twin-exhaust model
17.54	Gull 74*Obs* **94**, 1003.	Buoyancy model
17.55	Shklovskij 75*Pisma AZh* **1**, 7, 3.	Galaxy nucleus-black hole

18. *Statistics of Sources, Counts and Related Topics*

18.1	Evans 72*MN* **160**, 407.	Optical spectral indices
18.2	Rozyezka 72*Act. Astr.* **22**, 93.	Opt. galaxy counts around QSOs
18.3	Basu 73*NatPS* **241**, 159, **243**, 144.	Opt. selection effect
18.4	Smi *et al.* 73*ApJ* **181**, L61.	Opt. Hubble diagrams
18.5	Mills *et al.* 73*AJP* **26**, 417.	0.41 Molonglo
18.6	Plagemann 73*MN* **164**, 303.	3C Parkes
18.7	Maslowski *et al.* 73*AA* **28**, 289.	1.4 GB
18.8	Artynkh *et al.* 73*Soviet Astron.* **17**, 5.	0.086 Pushchino
18.9	Soltan 73*Act. Astr.* **23**, 311.	1.4
18.10	Machalski *et al.* 74*AA* **33**, 357.	1.4 GB
18.11	Crovisier *et al.* 74*AA* **34**, 285.	4.8 B2.1
18.12	Battistihi *et al.* 74*AA* **35**, 93.	Opt. radio B2
18.13	Katgert *et al.* 74*AA* **35**, 393.	1.4
18.14	Evans *et al.* 74*Obs* **94**, 45.	Opt
18.15	Gillespie 75*MN* **170**, 541.	1.4 5C
18.16	Wall *et al.* 75*MN* **171**, 9.	2.7, 5.0
18.17	Hills *et al.* 73*Annals N.Y. Acad. Sci.* **224**, 58.	Opt. Hubble. diagram. Brightest quasars
18.18	Gorshkov *et al.* 75*Pisma AZh* **1**, 9, 19.	8.6
18.19	Larionov 75*Astron. Tsirk.* *882*, 1.	8.6
18.20	Balonek *et al.* 75*ApJ* **201**, 20.	2.7
18.21	Gibson 75*AA* **39**, 377.	

(ii) *Interpretation and luminosity functions*

18.22	Roeder *et al.* 72*NatPS* **240**, 104.	Optical observational selection
18.23	Schmidt 72*Nat* **240**, 399.	Counts redshift
18.24	Yahil 72*ApJ* **178**, 45.	Anisotropy in distribution radio sources
18.25	Burbidge *et al.* 72*ApJ* **178**, 583.	Distribution of redshifts
18.26	Gorshkov *et al.* 72*Astron. Tsirk. 720*, 2.	New population of radiosources
18.27	Tovmassian 72*ApJ* **178**, L47.	Spiral galaxies
18.28	Soltan 72*Act.Astr.* **22**, 261.	Luminosity function of Gal.
18.29	Fanti *et al.* 73*AA* **23**, 161.	QSOs QSSs
18.30	Carswell 73*MN* **162**, 61.	Distribution of distant sources
18.31	Notni *et al.* 73*AN* **294**, 95.	Luminosity functions
18.32	Basu *et al.* 72*ASS* **19**, 303.	Redshift distribution
18.33	Vardanian *et al.* 72 *Soobshch. Byurakan. Obs.* **44**, 108.	Determination of completeness of lists
18.34	Fanti *et al.* 73*AA* **24**, 69.	Luminosity function.
18.35	Maslowski 73*AA* **26**, 343.	Anisotropy
18.36	Parijskij 73*Soviet Astron.* **17**, 4.	Evolution
18.37	Burbidge *et al.* 73*ApJ* **183**, 759.	Redshift magnitude
18.38	Karlsson 73*NatPS* **245**, 68.	Selection effects
18.39	Terebizh 73*Astrofiz* **9**, 209.	Quasar evolution
18.40	Stannard 73*Nat* **246**, 295.	Hubble diagram
18.41	Basu 73*Obs* **93**, 229.	Selection
18.42	Bell *et al.* 73*ApJ* **186**, 1.	Alternative to cosmological QSO
18.43	Van der Kruit 73*ApJ* **15**, 27.	Angular diameter distribution
18.44	Petrosian *et al.* 73*ApJ* **186**, 403.	Flux density-spectral index
18.45	von Hoerner 73*ApJ* **186**, 741.	Source counts and evolution
18.46	Burbidge *et al.* 73*ApJ* **186**, L59.	
18.47	Romano 73*Mem. Soc. Astron. Italiana, Nuova Ser.* **44**, 47.	Intergalactic absorption
18.48	Longair 74*IAU Symp.* **63**, 93.	Counts of radio sources.
18.49	Pauliny-Toth *et al.* 74 *IAU Symp.* **63**, 111.	Radio source counts at cm wav lengths
18.50	Fomalont *et al.* 74*AA* **36**, 273.	Improved count
18.51	Maslowski 74*AA* **36**, 395.	Spectral index distribution
18.52	Oven 75*ApJ* **195**, 593.	Luminosity function of Abell clusters
18.53	Terebizh 75*Astrofiz* **11**, 1.	Schmidt luminosity function of quasars
18.54	Gibson 75*AA* **39**, 377.	Orientation of double radio sources
18.55	Basu 75*ApJ* **16**, 53.	Effect misidentification

19. *Review Papers etc.*

(i) *Compendia of Data*

19.1	Robertson 73*AJP* **26**, 403.	All-sky catalogue
19.2	Conway *et al.* 74*MN* **168**, 137.	Radio polarization of quasars
19.3	Clark *et al.* 74*AJP* **27**, 713.	Catalogue of small diameter sources close to galactic plane
19.4	Veron *et al.* 74*AASup* **18**, 309.	Catalogue of extragalactic radio source identifications
19.5	Grandi *et al.* 74*PASP* **86**, 873.	Optical variability of quasars
19.6	Khachikian *et al.* 74*ApJ* **192**, 581.	Atlas Seyfert galaxies
19.7	Kraus *et al.* 75*AJ* **80**, 1.	Radio spectra, redshifts 179 QSO
19.8	Gallouet *et al.* 75*AASup* **19**, 1.	Optical positions of bright galaxies

(ii) *Reviews*

19.9	Sazonov 72*Uspekhi Fiz. Nauk* **108**, 583.	Circular polarization
19.10	De Young *et al.* 73*Comm. Astrophys. Space Phys.* **5**, 29.	Extended radio sources
19.11	Silvesto 73*Mem. Soc. Astron. Italiana, Nuova Ser.* **43**, 599.	High resolution methods
19.12	Heeschen 73*Trans. IAU* **15A**, 601.	Report of Commission 40 IAU
19.13	Troitskij 73*Uspekhi Fiz. Nauk.* **109**, 771.	VLBI in USSR
19.14	Kellermann *et al.* 73*Proc. IEEE* **61**, 1174.	Extragalactic radio sources
19.15	Kellermann 73*Phys. Today* **26**, 10.	Extragal. radio sources
19.16	Burbidge 73*NatPS* **246**, 17.	Problem of redshifts
19.17	Saslaw *et al.* 73*Comm. Astrophys. Space Phys.* **5**, 133.	Statistical properties Extragal. radio sources

19.18	Simon 73*Nat* **246**, 193.	Submillimetre astronomy
19.19	Hagen-Thorn 74*Astrofiz* **10**, 1.	Optical polarization of extragal. objects
19.20	Longair(ed) 74*IAU Symp.* **63.**	Cosmologica theories and observational data
19.21	Arp 74*IAU Symp.* **58**, 199.	Non-velocity redshifts
19.22	Blandtord 74*Obs.* **94**, 265.	Double radio sources
19.23	Tritton 74*Sci.Progr.* 242, **61**, 275.	Quasars and the redshifts
19.24	Shakeshaft (ed) 74*IAU Symp.* **58**.	Formation and dynamics of galaxies
19.25	Blandford *et al.* 75 *Contemp.Phys.* **16**, 1.	Double radio sources
19.26	Kinman 74*IAU Symp.* **67**, 573.	Variable quasars and BL Lac type objects
19.27	Van den Bergh 75*JRASC* **69**, 57.	Classification of normal galaxies
19.28	Thaddeus 72*ARAA* **10**, 305.	Short wavelength microwave background
19.29	Van den Bergh 75*JRASC* **69**, 105.	Classification of active galaxies

6. DEVELOPMENTS IN RADIO ASTRONOMY INSTRUMENTS

(B. J. Robinson)

A. *Radio Telescopes*

I. *Reflectors*

In 1973 the 100-m telescope of the Max Planck Institut für Radioastronomie in Germany became fully operational (**1**). It has performed well at wavelengths as short as 1.35 cm. On the CSIRO 64-m telescope in Australia an area 37 m in diameter has been resurfaced to operate at λ 1.35 cm, and a section 17 m in diameter resurfaced to operate at $\lambda \geqslant 5$ mm. The 43-m telescope at Green Bank, U.S.A. has been converted to Cassegrain optics. At the Arecibo Observatory in Puerto Rico the 305-m spherical reflector has been resurfaced (**2**) with aluminium panels for operation at $\lambda \geqslant 10$ cm. For delay-doppler planetary radar at Arecibo a 30-m reflector has been added to resolve position ambiguities by interferometry.

One sector of the RATAN 600 telescope (**3**) in the Caucasus is in operation at wavelengths between 2 cm and 6 cm. At λ 2 cm the beam is $11''$ arc $\times$ $15'$ arc. A Kraus-type reflector (**4**) 25 m $\times$ 2 m at Gorkii, U.S.S.R. has a $20''$ arc beam at λ 2 mm.

Radome-enclosed 13.7-m telescopes for short wavelengths have been built at the Itapetinga Radio Observatory in Brazil (**5**) and by the Helsinki University of Technology (**6**). A similar 13.7-m telescope is under construction in the U.S.A. at the University of Massachusetts, while a 20.1-m telescope is being built at the Onsala Space Observatory in Sweden. Design principles for mm-λ telescopes have been discussed by von Hoerner (**7**), while a novel trolley for accurate measurement of reflector profiles has been built (**8**).

Numerous small reflectors for mm-waves have been brought into operation. These include a 4.6-m telescope in Canada at the University of British Columbia (**9**), 1.5-m and 6-m telescopes in Japan at Kisaruzu Technical College and Tokyo Astronomical Observatory, and a 1-m telescope in the U.S.A. at NASA Institute for Space Studies. An 8.5-m telescope is under construction for Bell Telephone Laboratories (U.S.A.) and a 4-m telescope is being built for CSIRO in Australia. Optical telescopes at Lick and Palomar (U.S.A.) and at Siding Spring (Australia) have been used for mm-λ observations during daytime or full-moon periods.

II. *Aperture Synthesis Arrays*

Extensive descriptions of the operation and data handling of aperture synthesis arrays have been published. With the Fleurs Synthesis Telescope in Australia (**10–19**) observations are now being made at 1415 MHz with a 800-m NS arm, which is being extended to 1200 m while the 800-m EW arm is being extended to 1600 m. Details of the Westerbork array in The Netherlands

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have also been given (20–27); lower noise receivers have been fitted at λ 21 cm and work is in progress to double the baseline to 3 km by adding two 25-m dishes. A description has also been published of the 5-element synthesis array (28) at Stanford, U.S.A. The 5-km telescope at Cambridge (29) U.K. has been operated at 15 GHz where tropospheric phase errors are serious. At Cambridge an array of 42 elements at 151 MHz allows synthesis over a 1.5 km baseline; ionospheric phase errors have proved to be troublesome. A report has been published on the status of construction of the Very Large Array (30) in New Mexico, U.S.A.

At the Dominion Radio Astrophysical Observatory in Canada a synthesis array (31) for the 21-cm hydrogen line is now operating. The Cambridge, U.K. 'half-mile' telescope now has 4 elements with digital correlators.

Blum *et al.* (32) have searched for optimum synthetic linear arrays of 4 antennas used in 2, 3, 4 or 5 configurations.

III. *Interferometers and Arrays*

In Tasmania a 5×10^5-m^2 array for 2–20 MHz has been built as well as a 3×10^4-m^2 array for 40–160 MHz. In Florida, U.S.A., Jupiter studies have been made with an array of 640 λ/2 dipoles. At Clark Lake (U.S.A.) the 720 conical log-spiral elements of the 'Tee Pee Tee' array (33, 34) have been connected to form one beam (ultimately 49); operating frequency range is 15–130 MHz. Also at Clark Lake the COCOA-CROSS 7×10^4-m^2 array (35) has been built to observe interplanetary scintillations at 34 MHz. A 3.5-km interferometer system is being linked to the Ootacamund array (36) in India.

For pulsar observations an array 200 m × 400 m with 16 simultaneous beams at 102.5 MHz has been built at Pushino, U.S.S.R. At the University of Massachusetts, U.S.A. an array of four 36-m spherical reflectors is used to measure pulsars between 150 and 400 MHz.

The 2.7- and 8.1-GHz interferometer at Green Bank, U.S.A. has been extended to a baseline of 35 km with a radio link to a 14-m dish. The electronics for the original 3-element system have been described (37).

A number of mm-wave interferometers have been built or planned. At Hat Creek, USA two 6-m antennas can be located at 50 stations on a T-shaped track 300 m × 200 m; initial operation has been at λ 13.5 mm. At Bordeaux, France, two 2.5 m antennas on a 60 m baseline (38, 39) have been used for regular observations of the Sun and Venus. The Nagoya, Japan 8-element interferometer (40) at λ 8 mm is being rebuilt to give an EW resolution of 40″; a two-dimensional position determination (synthesis) takes 2 h. Massachusetts Institute of Technology, U.S.A. are mounting three 5.5-m dishes (good to λ = 5 mm) on a 300-m baseline with one dish one a 150-m track.

IV. *Radioheliographs*

The radioheliograph at Culgoora, Australia, now operates at three (41) frequencies – 43, 80 and 160 MHz; a fourth frequency of 327 MHz is being added. The 7.5 cm radioheliograph at Tokyokawa, Japan, has been extended to a T-array (42) with 16 elements NS and 34 elements EW; the central element is used for phase correction (43).

V. *VLBI*

Several accounts of *VLBI* techniques have been published (44–47). The problems of *VLBI* measurements at low frequencies have been described (48). Phase closure has been used to reduce instrumental phase effects. An improved and cheaper *VLBI* terminal (Mk IIC) has been developed in the U.S.A. An intercontinental *VLBI* array (49) has been proposed.

B. *Low-Noise Receivers*

Many observatories are now using cryogenically-cooled parametric amplifiers which offer system noise temperatures of 50 K to 80 K depending on input configurations. Lower system

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noise is offered by travelling-wave masers (**50**). System noise temperatures as low as 15 K have been achieved with T.W. masers used for spacecraft communication (**51**); these masers can be gain-stabilized by using a noise-adding radiometer (**52**). A wideband, tunable reflection maser has been built using a section of ruby-filled waveguide (**53**); the need for a circulator increases the noise somewhat.

At short cm and millimetre wavelengths cooled Schottky-barrier mixers followed by cooled parametric amplifiers (**54, 55**) offer noise temperatures of 300 K to 500 K. Similar noise performance has been obtained at wavelengths as short as 1.3 mm using an InSb bolometer as a mixer (**56**) but the bandwidth is less than 5 MHz. A comprehensive survey of mm-wave techniques has been published by Penzias and Burrus (**57**).

Significant progress has been made in the development of Josephson junction mixers and amplifiers (**58, 59**). Another new area under development is the cooling of FET's to give noise temperatures near 100 K.

C. *Spectrometers and Spectrographs*

A 1024-channel digital correlator (**60**) is in operation by CSIRO in Australia; two-bit correlation has shown the expected increase in sensitivity. Multi-level quantization has been used in a digital cross-correlator (**61**) at the Dominion Radio Astrophysical Observatory, Canada with 125 delays. An asynchronous correlator has been proposed by Ables.

A spectrometer for studying the fine structure of the Sun has been designed (**62**) in the U.S.S.R. while another has been built with high time resolution (**63**). A high-speed digital solar spectrograph (**64**) is operating at Clark Lake, U.S.A. At Culgoora, Australia a broad-band polarimeter has been built for solar bursts, while a novel spectrograph using electro-optical (**65**) processing has been installed. This electro-optic spectrograph has been tested (**66**) on the 64-m telescope at Parkes, Australia for recording broad OH profiles, and shows promise as a mm-wave spectrometer to analyse a 100 MHz band into 512 channels.

In Tasmania Ellis has developed a spectrum-analysis technique with high frequency- and time-resolution (**67**) by recording the signals on a videotape recorder and playing the tape back at reduced speed.

D. *Other Developments*

Techniques for pulsar de-dispersion, searching, data-handling and display have been described by Taylor (**68**).

Instrumentation of the Explorer-2 radio astronomy satellite (**69**) for 25 kHz to 13 MHz has been described.

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