

List of Tables

I	Forces acting on a Telescope (and Enclosure).	X
1.1	Radio Spectrum – Radiation Processes – Radio Telescopes.	3
1.2	Electromagnetic Reflector Diameter and Surface Precision.	8
2.1	Radio Telescope Design Parameters [in metre].	18
2.2.a	Thermal Sub-Structures of the IRAM 30–m Telescope.	25
2.2.b	Thermal Protection of the IRAM 30–m Telescope.	25
2.3.a	Thermal Sub-Structures of the IRAM/SEST 15–m Telescopes.	29
2.3.b	Thermal Protection of the IRAM/SEST 15–m Telescopes.	29
2.4	Approximate Masses of BUS Constructions.	33
2.5	BUS Dimensions.	34
2.6	Telescopes with Ventilation/Climatisation and/or Metrology.	38
2.7	BUS Ventilation and Climatisation Systems.	39
2.8	Telescope Materials (coefficients of thermal expansion).	44
2.9	Applied Passive and Active Thermal Control of Radio Telescopes.	46
2.10.a	Mount Structures.	47
2.10.b	Backup Structures.	47
2.10.c	Panel Constructions.	48
2.10.d	Quadripod Constructions.	48
3.1	Radio Telescope Enclosures.	51
3.2.a	Radio Telescope Enclosures: Radome (RD).	54
3.2.b	Radio Telescope Enclosures: Astrodome (AD).	54
4.1	Variation of Atmospheric Parameters with Height (average values).	58
4.2	Ambient Air Temperature: Seasonal Averages.	62
4.3	Thermal Properties of Grounds and Soils.	69
4.4	Thermal Properties of Water, Frost, Snow and Ice.	71
4.5	Difference ΔT_S of Sky Temperature and Ambient Air Temperature (Fig. 4.23).	78
4.6	Solar Radiation Absorption Coefficient a_S ($\sim 0.5 \mu m$).	81

4.7	Specification of Meteorological and Thermal Conditions.	82
5.1	Declination of the Sun throughout a Year.	87
5.2	Maximum Solar Illumination.	88
5.3	Solar Radiation captured inside a Radome or Astrodome.	102
5.4	Reduction of Solar Radiation on Subreflector.	106
6.1	Temperature Sensors on Telescope Structures.	109
7.1	Heat Capacities and Thermal Conductivities.	127
7.2	Values of h for Air and Water.	131
7.3	<i>Reynolds</i> Number RE_L for Flat Surfaces of Length L	135
7.4	<i>Reynolds</i> Number RE_D for Tubes of Diameter D	135
7.5	Average <i>Nusselt</i> Number NU_L and Heat Transfer Coefficient h_L [W/m ² /K] for a Flat Surface of Length L (laminar flow).	136
7.6	Average <i>Nusselt</i> Number NU_D , NU_{nD} for a Tube, and Bundle of Tubes, of Diameter D	137
7.7	Heat Transfer Coefficient h_D , h_{nD} [W/m ² /K] for a Tube, and Bundle of Tubes, of Diameter D	137
7.8	Paint Factor $E_{1,2}$ of Facing Walls.	143
7.9	Values $F = \mathcal{F}(273, 273 \pm \Delta T) / \mathcal{F}_0$	144
7.10	Approximate Values of e_1 ($3 \mu\text{m} \sim \lambda \lesssim 30 \mu\text{m}$).	145
7.11	External Thermal Time Constants τ_{ext} for \mathcal{R}_Σ as indicated.	158
9.1	Possible Degradation in Telescope Performance due to a Uniform Temperature Change (U), a Temperature Difference/Gradient (D) or a Random Temperature Change (R) in the specified Telescope Component.	173
9.2	Reported Thermal Behaviour of Alidade and Fork Support Structures. ...	179
9.3	Insulation Efficiency γ of Fork Structures.	189
9.4	Construction of Backup Structures.	204
9.5	IRAM 30–m telescope. Temperature Averages and RMS Deviations (no heating/cooling; average of 6 days).	219
9.6	IRAM 30–m telescope. Cosine–form Approximations of the Temperature Oscillations, Eq.(9.4) (no heating/cooling).	219
9.7	IRAM 30–m telescope. Energy Balance of the Temperature Oscillations (no heating/cooling).	220
9.8	Subreflector Support Structures (Quadripods).	242
9.9.a	Pedestal (Temperature T_P).	257
9.9.b	Alidade Towers (Temperature T_{A1} , T_{A2}).	257
9.9.c	Fork Support.	257
9.9.d	BUS Supports: Yoke, Central Hub, Invar Ring.	257
9.9.e	Backup Structure (BUS, T_B), without and with Ventilation.	258
9.9.f	Temperature Uniformity of Telescopes.	258
9.10	Global Thermal Time Constants of Telescope Components.	259
11.1	Complexity of Thermal Models.	274

11.2	Plate Panel and Aluminium–Honeycomb Panel.	275
11.3	Media–Lario TM Al–Honeycomb Panel, with front or back heating.	278
11.4	Thermal Protection with Façades.	285
11.5	Model of a Fork (IRAM 15–m Telescope).	286
11.6	Model of a BUS with Yoke and Focus cabin (IRAM 30–m Telescope). ...	294
11.7	Thermal Model of the Onsala Radome.	299
13.1	Temperature Tolerances of Reflector (BUS) Constructions (Eq.(13.1.b)). .	327
13.2	Temperature Tolerances of BUS Constructions (in ° C).	330
13.3	Alignment Errors.	333
13.4	Temperature Tolerances of the BUS, Quadripod and Telescope Support (in ° C).	337
13.5	Thermal Tolerance Criteria for Random BUS/Reflector Surface Deformations. 340	
13.6	Example of an Error Budget Table.	341
14.1	Similarity of Radio Telescopes and Optical Telescopes.	343
15.1	IRAM 30–m telescope. Zernike polynomial decomposition of Reflector Surface Deformations.	353
A.1	Parameters and Units.	358
A.2	BTU and SI Units.	358
A.3	Fundamental Constants.	359
A.4	Parameters used in Convective Heat Transfer.	359
C.1	Pointing Model Parameters.	364