

Cambridge University Press

978-0-521-11551-3 - The Solar Granulation, Second Edition

R. J. Bray, R. E. Loughhead and C. J. Durrant

Index

[More information](#)

NAME INDEX

- Adjabshirzadeh, A. 93
 Adrian, R. J. 131–4
 Ahlers, G. 123
 Aime, C. 38, 44, 66, 70–3, 76
 Albrechtsen, F. 76, 77
 Alissandrakis, C. E. 46
 Allen, M. S. 52
 Altrock, R. C. 190–2, 210, 211
 Alvensleben, A. von 36
 Ambrož, P. 219
 Ando, H. 78
 Andreiko, A. V. 42, 44, 46, 47, 55, 75
 Athay, R. G. 176
 Auer, L. H. 184
- Babcock, H. D. 12
 Babcock, H. W. 12
 Bahng, J. 70
 Bannister, T. C. 116
 Banos, G. J. 42, 45
 Barletti, R. 29, 38
 Bässgen, M. 94
 Beckers, J. M. 60–2, 64, 86, 92, 172, 194, 219, 223, 224
 Behringer, R. P. 123
 Bénard, H. 11, 116
 Bhatnagar, A. 194
 Biermann, L. 11
 Birkle, K. 44, 45
 Blackwell, D. E. 17, 39, 46, 47, 70, 212
 Block, M. J. 116
 Böhm, K. H. 115, 152, 189
 Böhm-Vitense, E. 11, 143, 144, 148, 149
 Borgnino, J. 94
 Bradshaw, P. 127
 Brandt, P. N. 28, 32–5, 217–19, 221
 Bray, R. J. x, 19, 23, 30–2, 39–44, 46, 47, 49–51, 53–5, 62–4, 66, 77, 83, 87, 88, 92–4, 131, 214, 225
 Breckinridge, J. B. 217
- Bruggencate, P. ten 15
 Bruner, E. C. 86
 Bumba, V. 214
 Busse, F. H. 112, 117, 122, 123, 125
- Canfield, R. C. 70, 79–84, 189–92, 194, 210
 Cannon, C. J. 182, 184
 Carlier, A. 52
 Ceppatelli, G. 29, 38, 55, 57, 94
 Chan, K. L. 184
 Chandrasekhar, S. 37, 106, 110, 113
 Chauveau, F. 52
 Chevalier, S. 8, 9, 15, 18
 Clever, R. M. 123
 Cloutman, L. D. 187, 198–202, 204, 207, 208, 215
 Coulman, C. E. 37
 Cox, J. P. 102, 110, 140, 143
 Cram, L. E. 88
 Cuny, Y. 189
- Dainty, J. C. 38
 Daniels, P. G. 117
 Danielson, R. E. 86
 Dawes, W. R. 2, 5, 18
 Dearsdorff, J. W. 118, 123
 Deubner, F. L. 67–75, 77, 78, 85, 86, 91, 94
 Deupree, R. G. 164–7
 Dewhirst, D. W. 17, 39, 46, 47, 70
 Diemel, W. E. 40–4, 48, 70, 73, 196
 Dodson, H. W. 215
 Dollfus, A. 17, 39, 46, 47, 70
 Dravins, D. 61, 203, 205, 217, 218, 220, 224, 225, 227
 Dryden, G. 72
 Dunn, R. B. 37, 40, 44, 50, 52, 88
 Durney, B. R. 149

Cambridge University Press

978-0-521-11551-3 - The Solar Granulation, Second Edition

R. J. Bray, R. E. Loughhead and C. J. Durrant

Index

[More information](#)

248

Name index

- Durrant, C. J. 74, 76, 79–81, 84, 190, 191, 211, 228
 Duvall, T. L. 91
- Edmonds, F. N. 46, 47, 53, 54, 57, 58, 64, 70, 71, 74, 83, 85, 87, 88, 91, 145, 192, 210, 211
 Eichler, D. 168
 Elias, D. 45
 Eschrich, K. O. 156
 Evans, J. W. 70, 78, 91
- Frazier, E. N. 81, 91, 92
 Frenkiel, F. N. 15
 Fried, D. L. 37, 38
- Gaustad, J. 46, 70
 Gebbie, K. B. 92
 Gilman, P. A. 137
 Gingerich, O. 189
 Giovanelli, R. G. 92, 177, 193
 Giuli, R. T. 102, 110, 140, 143
 Glatzmaier, G. A. 137
 Goddard, W. 129, 131, 133
 Goldstein, R. J. 117
 Gollub, J. P. 168
 Gough, D. O. 104, 106, 114, 115, 125, 139, 141–7, 149, 157, 163
 Gouttebroze, P. 184
 Graham, D. J. 117
 Graham, E. 115, 163–6
 Gray, D. F. 225–7
 Grec, G. 44
 Griffin, R. (Rita) 227
 Griffin, R. (Roger) 227
 Grodzka, P. G. 116
 Gross, D. 129, 131, 133
 Gurman, J. B. 86
- Hagyard, M. J. 86
 Hall, P. 117
 Hansen, T. L. 76, 77
 Hansky, A. 8, 9, 15, 18
 Hart, A. B. 147, 160
 Hart, M. H. 88, 91
 Harvey, J. W. 40
 Hathaway, D. H. 137
 Heasley, J. N. 181, 182
 Hedeman, E. R. 215
 Heintze, J. R. W. 189
 Hejna, L. 44
 Henze, W. 86
 Herschel, W. 1, 18
 Hinkle, K. H. 70, 71, 74
 Hoo, L. S. 129, 131, 133
 Howard, R. 78, 167, 194, 219
 Hubenet, H. 189
- Hufnagel, R. E. 38
 Huggins, W. 4, 18
 Hugon, M. 49–52
 Hyder, C. L. 86
- Ibbetson, P. A. 212
- Jager, C. de 11, 53, 189
 Janssen, P. J. 5–9, 15, 18
 Jenkins, G. M. 65, 83
 Jones, C. A. 123, 125, 209
 Jones, H. P. 184
- Kaisig, M. 220, 228
 Kalkofen, W. 189
 Kallistratova, M. A. 32
 Karpinsky, V. N. 21, 36, 39, 40, 42, 44, 46, 47, 55, 59, 70–3, 75–7, 83
 Kato, S. 114
 Kawaguchi, I. 44, 51–3
 Keenan, P. C. 15
 Keil, S. L. 42, 46, 62, 70, 74, 75, 79–82, 84, 94, 173, 189–92, 210, 211
 Keller, G. 27
 Kiepenheuer, K. O. 8
 Kirk, J. G. 60
 Kitai, R. 52
 Kleczek, J. 214
 Klüber, H. von 15
 Kneer, F. 76, 84, 93, 181–3, 189, 190
 Knobloch, E. 156
 Knölker, M. 70
 Koch, A. 220
 Kolmogoroff, A. N. 13–15
 Korff, D. 72
 Koschmieder, E. L. 117, 119
 Koutchmy, S. 93
 Kovaszny, L. S. G. 66
 Krat, V. A. 21, 36, 46, 70
 Krause, F. 156
 Krishnamurti, R. 118–20, 122, 123, 126
 Küveler, G. 220
- LaBonte, B. J. 40, 44, 50, 52, 167
 Landau, L. D. 97, 100
 Langley, S. P. 2, 5
 Latour, J. 157–60, 167, 184
 Ledoux, P. 168
 Legait, A. 184
 Lejbacher, J. W. 184
 Leighton, R. B. 16–18, 25, 26, 70, 78, 88–91, 208, 209, 214
 Lévy, M. 70, 71, 180
 Liepmann, H. W. 128
 Lifshitz, E. M. 97, 100
 Lindegren, L. 61, 203, 205, 217, 218, 220, 224, 225

Cambridge University Press

978-0-521-11551-3 - The Solar Granulation, Second Edition

R. J. Bray, R. E. Loughhead and C. J. Durrant

Index

[More information](#)*Name index*

249

- Lites, B. W. 176
 Livingston, W. C. 60, 86, 228
 Lockyer, J. N. 5
 Lohmann, A. W. 37
 Lorenz, E. N. 168
 Lortz, D. 117, 123
 Loughhead, R. E. x, 19, 23, 30–2, 39–44,
 46, 47, 49–51, 53–5, 62–4, 66, 77, 83,
 87, 88, 92, 94, 131, 214, 225
 Lumley, J. L. 127
 Lyot, B. 16, 49

 McMath, R. R. 15, 16
 Macris, C. J. 16, 18, 39–42, 44–6, 49, 50,
 91
 Makita, M. 114
 Malkus, W. V. R. 118, 119
 Maluck, G. 75, 76
 Marcus, P. S. 228
 Margrave, T. E. 193, 194
 Martin, F. 44
 Massaguer, J. M. 160–3, 212
 Matsushima, S. 150, 158
 Mattig, W. 25, 36, 70–5, 77, 79–82, 84,
 189–91
 Mehlretter, J. P. 36, 42, 44, 48–52, 70, 71,
 74, 75, 77, 79, 82–4, 88, 93
 Meinel, A. B. 27
 Mekhanikov, V. V. 71–3
 Michard, R. 40, 70, 78, 83, 85, 91
 Mihalas, B. W. 131, 212
 Mihalas, D. 170, 174, 176
 Milkey, R. W. 172
 Miller, M. G. 72
 Miller, R. A. 87
 Moffatt, H. K. 128
 Mohler, O. C. 15
 Moore, D. R. 114, 115, 123–5, 130–1, 144,
 163, 168, 209
 Moore, D. W. 128, 148
 Moore, R. L. 93
 Morrison, R. A. 60–2, 64
 Morse, P. M. 101
 Mullan, D. S. 145
 Muller, R. 44, 54–7, 93
 Muncaster, R. G. 97
 Murphy, J. O. 125
 Musman, S. 39, 52, 79, 85, 130, 190, 191,
 194–6, 202, 207, 209–12, 223
 Myrup, L. 129, 131, 133

 Namba, O. 40–4, 48, 52, 70, 73, 196
 Nasmyth, J. 1–5, 18
 Naze Tjötta, J. 215
 Nelson, G. D. 188, 194–202, 207–12, 223,
 224, 227
 Nesis, A. 74, 79–82, 84, 189–91, 211

 Nordlund, A. 61, 150, 151, 202–5, 207–9,
 213, 217, 218, 220, 224, 225
 Normand, C. 108
 Norton, D. G. 31
 November, L. J. 92
 Noyes, R. W. 78, 89–91, 189

 Öpik, E. J. 141, 143, 144, 149
 Osaki, Y. 78
 Owocki, S. P. 184

 Pallas, S. G. 119
 Palm, E. 117, 118
 Parsons, S. B. 151
 Paterno, L. 29, 38
 Pearson, J. R. A. 116
 Petford, A. D. 212
 Pierce, A. K. 15, 217
 Plaskett, H. H. 11, 18, 53, 116, 187
 Pomeau, Y. 108
 Prandtl, L. 11, 18, 138, 140, 141
 Pravdjuk, L. M. 42, 44, 46, 47, 55, 75–7
 Press, W. H. 228
 Priestley, C. H. B. 29, 31, 209
 Prokakis, T. J. 50

 Ramsey, H. E. 40
 Rayleigh, Lord 107, 108, 110, 116
 Reiss, G. 79–81, 190, 191
 Rhodes, E. J. 78
 Richardson, R. S. 12–15, 17, 18, 58, 82
 Richter, E. 115
 Ricort, G. 38, 66, 70–3, 76, 94
 Righini, A. 29, 38, 94
 Rijsbergen, R. van 52
 Roddier, F. 37, 44
 Rösch, J. 16, 18, 19, 27, 41, 42, 44, 46,
 49–54
 Roxburgh, I. W. 153
 Rüdiger, G. 156
 Rush, J. H. 82

 Schlüter, A. 117, 123
 Schmidt, B. 10
 Schmidt, W. 70, 71, 74, 75, 79–81, 190,
 191
 Schröter, E. H. 40, 41, 44, 70, 75, 189,
 217–21, 228
 Schwarzschild, K. 109
 Schwarzschild, M. 12–15, 17–20, 46, 70,
 82, 110, 168
 Secchi, A. 2, 4
 Segel, L. A. 117
 Semel, M. 86
 Servajean, R. 83, 85
 Shine, R. A. 86
 Siedentopf, H. 10, 11, 18

Cambridge University Press

978-0-521-11551-3 - The Solar Granulation, Second Edition

R. J. Bray, R. E. Loughhead and C. J. Durrant

Index

[More information](#)

250

Name index

- Simon, G. W. 40, 44, 49, 50, 52, 78, 88–92, 208, 209, 213, 214
 Skumanich, A. 15, 115, 184
 Slaughter, C. 92
 Smith, J. E. 86
 Smithson, R. C. 37
 Sobolev, V. M. 36, 46, 70, 71, 194
 Sofia, S. 184
 Speroni, N. 29, 38
 Spiegel, E. A. 114–16, 125, 139, 144, 146, 150, 157–60, 163, 167, 168, 179, 187, 210
 Spruit, H. C. 144, 146, 149, 188, 199
 Stanley, N. R. 38
 Steshenko, N. V. 86
 Stix, M. 113
 Stock, J. 27
 Stone, E. J. 2
 Strebelt, H. 9, 10, 15, 16, 18, 39
 Stuart, F. E. 82
 Stuart, J. T. 117, 118
 Swihart, T. L. 193, 194
 Swinney, H. L. 168
- Tandberg-Hanssen, E. 86
 Tappere, E. J. 31, 62, 64, 83, 88, 93
 Tarbell, T. D. 37
 Tatarski, V. I. 37
 Tavakol, R. K. 153
 Taylor, W. R. 219
 Tennekes, H. 127
 Teukolsky, S. A. 228
 Tjötta, S. 215
 Toomre, J. 92, 125, 131, 157–60, 167, 184, 212
 Townsend, A. A. 131, 133, 135
 Travis, L. D. 150, 158
 Truesdell, C. 97
 Turner, J. S. 148, 209
 Turon, P. 193
- Uberoi, M. S. 15, 66
 Ulrich, R. K. 78, 148, 150, 151, 180, 210
- Unno, W. 114, 154–8
 Unsöld, A. 10, 18, 189
- Valverde, M. G. 108
 van der Borcht, R. 158–63, 228
 Vardya, M. S. 102
 Veronis, G. 118, 119, 130
 Vickers, G. T. 115
 Voigt, H. H. 189, 216
- Walton, I. C. 117
 Wasiutynski, J. 11, 154
 Waters, B. E. 158
 Watts, D. G. 65, 83
 Webb, C. J. 83, 85, 91
 Webb, E. K. 29–31
 Weigelt, G. P. 27, 37
 Weiss, N. O. 114, 115, 123–5, 130, 131, 143–5, 149, 163, 166, 213, 214
 Weizsäcker, C. F. von 14
 Werner, W. 84, 189, 190
 West, E. A. 86
 Whitehead, J. A. 117, 122
 Wiesmeier, A. 74
 Willis, G. E. 118, 123
 Willis, R. B. 212
 Wilson, P. R. 192, 193
 Winter, J. G. 31
 Wittmann, A. 42, 46, 47, 70, 74
 Wöhl, H. 25, 32–4
 Wolff, C. L. 184
 Woodgate, B. E. 86
 Woolley, R. v. d. R. 11
 Worden, S. P. 91, 92
- Yackovich, F. H. 94
 Yih, C. S. 97
 Young, A. T. 33, 37
 Young, C. A. 5
- Zachariadis, T. G. 46
 Zahn, J. P. 157–63, 167, 184, 212
 Zirker, J. B. 88

SUBJECT INDEX

(Note: unless otherwise apparent, entries refer to the *photospheric* granulation.)

- abnormal granulation, *see* disturbances in active regions
 - effect on granulation? 88, 219–21, 228
 - fine structure of magnetic field 86, 88
- anelastic approximation, *see* convective theory
- balloon-borne observatories
 - Soviet Stratospheric Solar Observatory 21, 36, 40, 55, 71–3, 75–6
 - Spektrostratoskop 36, 48–9, 51, 74–5, 82
 - Stratoscope 14, 17–20, 36, 45, 53, 64, 74, 88
- Boussinesq approximation, *see* convective theory
- brightness
 - centre-limb variation of rms 74–5, 146, 150, 193
 - distribution across a granule 46–7, 77
 - diversity in 47–8
 - rms, continuum 67–77
 - rms, in Fraunhofer lines 75–6
 - rms, theoretical 204
 - wavelength variation of rms 75–7
 - see also* statistical properties
- brightness–size correlation 17, 47–8
- brightness–velocity correlation 12–13, 58–60, 82–3
- Brunt–Väisälä frequency, *see* internal gravity waves
- C-shape, *see* Fraunhofer lines
- cell size
 - observed 41–5, 73–4
 - theoretical 112–15, 158–9, 161, 165, 167, 199, 207
- cell size of supergranulation 88–91
- cellular pattern 5, 7, 9–10, 15–17, 19, 39, 44, 95
- changes in individual granules, *see* evolution
- contrast 45–6, 60, 62, 77, 191
- contribution function, *see* radiative transfer theory
- convection
 - calculation of solar and stellar models 110, 152
 - classical Rayleigh problem 110–13
 - efficiency 142–3, 145, 152, 201, 212
 - forced 29–30, 128–9
 - in Nature 29–30, 33, 208–9
 - in the stars xi–xii, 152
 - nature of turbulent 133–5, 153–4, 168, 206
 - penetration 129
 - thermals vs. eddies 146, 148, 150, 168
 - see also* convective models, convective overshoot, convective theory, experiments on convection, Rayleigh number, solar convection zone
- convective heat flux in solar photosphere
 - observed 193, 210–11
 - theoretical 196, 210–11, 224
- convective instability criterion
 - Rayleigh 109
 - Schwarzschild 55, 109–10
- convective models, linear 111–15, 207
 - applied to polytropic atmosphere 115–16
 - applied to solar convection zone 152–3, 207
 - limitations of 116, 153, 207
- convective models, non-linear
 - anelastic 157–62, 184, 194–5, 202–3, 227, 228
 - applied to granulation 194–5

- applied to polytropic atmosphere 158–65, 184
- applied to solar convection zone 168–9, 184, 228
- applied to stellar convection zones 159–60, 165–6, 212
- applied to stellar granulation 227
- Boussinesq 117–18, 123–6, 137
- full 163–6, 184, 198–201
- convective overshoot
 - definition 129
 - in laboratory 129–35
 - interfacial layer 129–30, 133–4, 189
 - linear theory 130
 - non-linear theory 130–1
- convective theory
 - anelastic approximation 102–6
 - Boussinesq approximation 106–7
 - convective heat flux 123–5, 142–3, 148, 150–2
 - eddy dynamics 146–9, 168–9, 200–1, 204–5
 - eddy (turbulent) viscosity 146–7, 153, 155–6, 158, 199, 202
 - flow pattern 160–1, 164–6, 199–201, 203–5
 - fundamental mode 112, 152
 - growth rate 111–12, 115, 147–8, 152
 - harmonic mode 66, 111, 147, 157
 - linearized 111–16, 207
 - mean temperature gradient 161–2, 167, 187–8, 198, 201
 - mixing-length, *see* mixing-length theories
 - modal analysis 111, 135, 157–9, 167, 169, 202
 - onset of convection (Rayleigh problem) 108–16, 130
 - role of planform 159–61
 - role of pressure 107, 160–1, 164, 196, 207, 212
 - role of radiative transfer 151, 181–2, 184
 - scale of motion 149, 159–60, 164–6, 169, 184, 199, 207–8, 213–14
 - vorticity 120–1, 123–5, 127, 199
 - see also* convective models, convective overshoot, mixing-length theories
- dark lanes, intergranular 2, 5, 9, 12, 16–17, 19, 39–41, 45
- dark regions 19, 42
- dark spot 52, 207
- diagnostic diagrams, *see* statistical properties
- diameter, of individual granules
 - early measurements 2, 5, 9
 - in undisturbed regions 17, 19, 39–41, 47
 - near sunspots 41, 86
- diffusion approximation, *see* radiative transfer
- disturbances in abnormal granulation 56, 86–8
- early observations
 - chronological summary 18
 - historical survey 1–18
 - photographic 5–9, 18
 - visual 1–5, 18
- Eddington approximation, *see* radiative transfer
- Eddington–Barbier relation, *see* radiative transfer
- evolution
 - observed 8, 17, 50–3
 - theoretical 168, 201, 204–5
- experiments on convection
 - Bénard’s 11, 116
 - cell shape 112, 117–18
 - convective heat flux 118–20, 133
 - convective overshoot 129, 131–5
 - critical Rayleigh number 117
 - direction of circulation 117–18
 - effect of surface tension 8, 116
 - steady 117–19, 126
 - time-dependent 122–6
 - turbulent 123, 126, 131–5
- ‘exploding’ granules 48, 52, 203, 207
- extension into upper photosphere 53–64, 75–6, 79–82, 84–5
- faculae, photospheric
 - facular granules 56–7, 93
 - facular points 93
 - filigree 87–8
 - relation to abnormal granulation 56–7, 88
 - see also* network, photospheric
- families of granules 53, 74, 87, 94
- foreshortening near limb 54–5
- formation and dissolution of individual granules
 - observed 50–3
 - theoretical 168, 201–5
- fractional area covered by granules 41–2
- fragmentation of granules, *see* ‘exploding’ granules
- Fraunhofer lines
 - asymmetry, centre-limb variation 218, 221
 - asymmetry, in stars 225–7
 - asymmetry of mean profile (C-shape) 61, 216–24
 - central intensity correlation with continuum fluctuations 84–5
 - Doppler shifts, *see* velocity

Subject index

253

- gravitational redshift 217
 interpretation of asymmetry and shift 216, 221–4
 profiles of ‘hot’ and ‘cold’ elements 60–1, 216
 rms central intensity 75–6
 wavelength shifts (mean profile) 216–18
 wavelength shifts, in stars 227
see also radiative transfer theory, height of formation
- giant cells, hypothetical 104, 167, 184, 214–15
- granule, introduction of term 4–5, 18
- gravity waves, *see* internal gravity waves
- Harvard–Smithsonian Reference Atmosphere, *see* homogeneous models of photosphere
- height of formation
 of continuum 57–8
 of Fraunhofer lines 57–8, 75–6, 81, 84
- height of overshoot, *see* extension into upper photosphere, interpretation of observed properties
- homogeneous models of photosphere 146, 188–9, 195
- hydrodynamic equations
 anelastic 105, 137, 154, 158, 195, 228
 Boussinesq 106–7, 110, 141
 general 97–102
 mean-field 130, 147, 153, 159
- image blurring, *see* seeing, solar
- image motion, *see* seeing, solar
- inhomogeneous models of photosphere 185, 187–98
 empirical 188–94
 limitations of empirical 193–4
 semi-empirical 194–8
- inhomogeneous models of stellar photospheres 227
- instrumental profile 28–9, 37–9, 45–6, 66, 71, 79
- interfacial layer, *see* convective overshoot
- intergranular lanes, *see* dark lanes, intergranular
- internal gravity waves 130–1, 133, 135
 Brunt–Väisälä frequency 109, 131
 in solar atmosphere? 211–12
 interaction with convective motions 131, 133, 135
 radiative damping 136
- interpretation of observed properties
 as a convective phenomenon 10–13, 15–16, 25, 48, 83, 85, 95, 186–7, 223–4
 cellular appearance 186, 206
 direction of circulation 212
 evolution 209
 height of overshoot 209–12
 lifetime 208–9
 mean cell size 206–8
 role of non-uniform radiative transfer 181–4, 192–3
 source of energy 10–11, 18, 95, 186–7, 199, 204
 turbulence spectrum 212–13
 velocity–brightness correlation 83, 85, 186
 visibility near limb 209
- isoplanatic patch, *see* seeing, solar
- Kelvin–Helmholtz instability 108, 215
- Kolmogoroff’s law 13–14, 128, 212
- lifetime of individual granules
 early measurements 8, 18
 observed 16, 18, 49–50
 theoretical 201, 204
- limb appearance 53–5, 63–4
- line-spread function, *see* instrumental profile
- Mach number 104, 161–2
- magnetic field of active regions, fine structure 86, 88
- magnetic field of individual granules 86
- mesogranulation 53, 92, 94
- microturbulence 194, 212–13
- mixing-length theories 11, 18, 139–53, 167, 210
 local 141–9
 limitations of 149
 non-local 149–51
vis-à-vis turbulence 140, 168
- modulation transfer function, *see* instrumental profile
- network 86
 chromospheric 91
 photospheric 56–7, 67, 88, 92, 215
 relation to abnormal granulation 56, 88
- number of granules on Sun 44
- Nusselt number 118–19, 125, 152
see also convective heat flux in solar photosphere
- observatories
 Allegheny 2
 Big Bear 32
 Capri 32–3, 35, 72
 Crimea 8
 Culgoora (CSIRO) 19, 23, 31, 42, 62–3
 Izaña 25, 32–5, 71, 73
 Kitt Peak 28, 35, 58–9
 La Palma (Muchachos) 32–4
 McMath–Hulbert 15–16

- Meudon 5, 6, 8
 Mt Wilson 12, 16, 58, 82, 88
 Munich 10
 Oslo 76
 Oxford 11, 88
 Pamir 59
 Pic-du-Midi 16, 33, 51–2, 55–6, 71
 Potsdam 15
 Princeton 12
 Pulkovo 8
 Royal Greenwich 2
 Sacramento Peak 33, 35, 50, 60, 62, 67,
 72, 79–80, 87, 92
 Sydney (CSIRO) 16–19, 23, 32, 54
 Yerkes 15
 Zô-Sè 8–9
 oscillatory velocity field, *see* velocity,
 oscillatory motions in upper photo-
 sphere
 overshoot, *see* convective overshoot

 Pécelet number 156, 158
 penumbral bright grains, *see* sunspots
 photography of granulation
 beginning of modern era 16–18
 early history 5–10, 18
 from manned balloon 17–18
 from unmanned balloon, *see* balloon-
 borne observatories
 photometry, *see* contrast, brightness,
 statistical properties
 photospheric models, *see* homogeneous
 models, inhomogeneous models, solar
 convection zone
 photospheric structures, summary of
 properties 93
 plumes, convective
 in boundary layer of Earth's atmosphere
 29–31, 209
 in developed convection 122, 124–5,
 134–5
 in solar convection zone? 209
 point-spread function, *see* instrumental
 profile
 polygonal appearance, *see* shape
 polytropes 105–6, 114–15
 pores, sunspot, *see* sunspots
 'porules', *see* dark regions
 power spectrum, *see* statistical properties
 Prandtl number
 definition 111, 156
 in solar convection zone 127, 145
 role in convective dynamics 121–6,
 159–60, 165–6

 radiative transfer theory 169–84, 192–3
 basic equation 170
 contribution function 57–8, 172
 cooling times in solar photosphere
 180–1
 diffusion approximation 176–8, 184,
 196, 198
 Eddington approximation 176–8, 181–2,
 184, 193, 195, 203
 Eddington–Barbier relation 57, 75–6,
 103, 171–2
 local thermodynamic equilibrium (LTE)
 175–7, 179, 183–4, 195–6
 non-uniform 55, 57, 75, 176–84
 non-uniform, applied to granule observa-
 tions 181–4, 191–3
 radiative conductivity 178
 radiative cooling 151, 179–81, 203, 209
 radiative equilibrium 181, 193
 radiative heat flux 170, 177–8, 180
 source function 171, 173–6, 195
 two-dimensional solutions 181–4, 192–3
 weighting functions 82, 172–3, 191, 222
 Rayleigh criterion, *see* convective instability
 criterion
 Rayleigh number
 breakdown of steady flow 122–3, 126
 critical 110, 112–14, 117
 critical, for multilayer fluids 113, 130
 critical, for polytropic atmosphere 114–
 15
 definition 109, 111, 114, 130, 153
 effect on heat transport 118–19, 125
 in solar convection zone 127, 145
 role in non-linear theory 112, 123–5,
 161, 164–5
 Rayleigh–Taylor instability 107–8, 199
réseau photosphérique 6, 8
 Reynolds number 11, 122, 156, 158
 'rice grains' 2

 Schwarzschild criterion, *see* convective
 instability criterion
 seeing, solar
 comparison between observatories 33–5
 dependence on height 29–33
 Fried parameter 38, 72, 94
 image blurring 27–8, 32–5, 94
 image motion 27–8, 94
 implications for telescope location 31–5
 influence of local terrain 33
 instrumental compensation for 37–8
 intermittency 30–1, 35
 isoplanatic patch 37
 magnitude of temperature fluctua-
 tions 31
 origin 26–35, 94
 seeing disk 28
 speckles 27, 38

- statistics 32–5
- theory of image distortion 26–7, 37–8, 72
- see also* instrumental profile, *réseau photosphérique*
- shape, of individual granules 2–5, 10, 18–19, 25, 38–9
- size, of individual granules
 - diversity in 19, 41–3, 47–8
 - see also* diameter
- solar convection zone, physical conditions
 - in 143–6, 169, 186–8, 198–9, 213–14
 - convective heat flux 144
 - density 187–8
 - effective thickness of granulation layer 169, 208
 - effective thickness of supergranulation layer 169, 214
 - gas pressure 144, 188
 - ionization energy 10, 95, 186–7
 - kinematic viscosity 145
 - Prandtl number 127, 145
 - radiative conductivity 145
 - Rayleigh number 127, 145
 - temperature 144
 - temperature gradient 144, 188, 198, 201
 - thickness 144–6
 - ‘turbulence’ 11, 13–14, 18, 138
- solar cycle, dependence on 44–5
- solar rotation
 - effect on giant cells 104
 - effect on granulation 103
 - effect on supergranulation 103, 137
- solar seeing, *see* seeing, solar
- statistical properties 64–85
 - brightness power spectrum 65, 68–9, 72–4
 - coherence 83–5
 - correction for instrumental profile and seeing 38, 66, 71–3, 77, 79
 - diagnostic diagrams 67–9, 78–80
 - spectral analysis 64–7
 - time lag between brightness and velocity 85
 - velocity power spectrum 68–9, 78–9
- stellar convection zones xi–xii
- stellar granulation 225–8
- structure within individual granules 40, 52
- summary of observed properties 93
- Sun, spectral class xi
- sunspots
 - appearance of granulation near 41, 56, 86–7
 - penumbral bright grains 93
 - pores 4, 19, 87
 - umbral dots 93
- supergranulation 82, 88–94
 - as brightness pattern 92
 - cell size 88–91
 - convective model 228
 - discovery 78, 88
 - due to helium ionization 214
 - due to mechanical effects 215
 - effective layer thickness 214
 - horizontal velocities 88, 91
 - interpretation of observed properties 213–15
 - magnetic field at cell boundaries 86, 92
 - number of supergranules on Sun 90
 - observed properties 90–2
 - relationship to network 67, 91–2
 - summary of properties 93
 - supergranule diameters 88, 90–1
 - supergranule lifetimes 88
 - transport of granules 91
 - velocity pattern 89–90
 - vertical velocities 92
- surface density of granules 43–4
- telescope, instrumental profile of, *see* instrumental profile
- temperature fluctuations
 - observed (rms) 189–91
 - theoretical 193, 196–7, 201, 205
- thermals 128, 148
- turbulence
 - as model for convection 13–14, 157–8, 168–9
 - drag due to 195–6, 202
 - dynamics of 127–8
 - in Earth’s atmosphere 29, 37–8, 72, 94, 135
 - mixing-length model of 154–6
 - structure of 128, 134–5
 - ‘turbulent elements’, attempts to identify granules as 13–15
- umbral dots, *see* sunspots
- velocity, large-scale field in upper photosphere, *see* supergranulation
- velocity 57–64, 77–85, 190–1
 - correlation with continuum brightness 12–13, 58–60, 82–5
 - extension into upper photosphere 57–8, 64, 79–82, 85, 94, 190–1
 - first spectroscopic observations 12, 18, 58
 - magnitude, observed 12, 62, 64, 190–1
 - magnitude, theoretical 196–7, 200–1, 204, 208

- pattern 61
- rms 79–82, 190
- spatial resolution of spectral measurements 12, 19, 23, 67
 - see also* statistical properties
- velocity, oscillatory motions in upper photosphere 25, 64, 78–9, 80–2
 - as cause of supergranulation? 215
 - dependence on height 79–80
 - discovery 78
 - nature of 78
 - no effect on granules 223
- periodicity 78
 - separation from granular motions 64, 78–81
- visibility near limb, *see* extension into upper photosphere, limb appearance
- weighting functions, *see* radiative transfer theory
- Wien's law 75, 103
- 'willow-leaf' pattern 2, 3, 18