extinction curve 184 extragalactic astronomy 191 et for the amateur 212-3 extragalactic objects, drawing 212 photographing 212-3 faculae 82 filters, U,B,V 44 narrow band 238 fireball(s) 157 patrols 30, 162 fireball stage 226 Fisher, Richard 198 Fitzgerald, George 218 Fizeau, Hippolyte 46 flattening of galaxies 191 'forbidden transitions' 178-9 Ford, Kent 198, 207 Fornax galaxies 199 frames of reference 216, 218 Fraunhofer, Joseph 45 'free fall' 220 fretted terrain (Mars) 125 Friedmann, Alexander 224 function 49 galactic 191 galactic (open) clusters 12, 60, 173 galactic objects, drawing, 176 photographing **176-7** galactic plane 155, 166 galaxian 191 galaxian wind 201 galaxies **191** et seq active 191, **207** et seq classes of 207 et seq emission by 207 et seq energy sources 210 Markarian 208 M87 210 N-type 208 Seyfert 207 age of 193, 214 anaemic (see galaxies, spiral, anaemic) binary 205 classification of 191 et seq de Vaucouleurs 193, 196 Hubble 191 Morgan 194 physical significance 192 Van den Bergh 194 clusters of **203** et seq, 204 Coma 203, 204, 205 distribution 204 intergalactic matter 204 et seq irregular 203 masses of 204 et seq matter between 206 missing mass 204-5 regular 203 size of 203 and spiral content 203 stability of 205 superclusters **204** types 203 Virgo 203 X-ray emission by 204, 205 colour of 200 compact 208 distribution of 192 distance of, methods of measurement 197 et seq dust in 192, 200 dwarf 208 elliptical 208 elliptical 191 and BL Lacertae objects 209 blue giants within 200 cD 194, 201, 202, 203 dwarf 194, 199 dwarf, companions to Galaxy 199 ellipticity of 191-2, 201 giant 194, 202, 203 hydrogen content 201 interstellar matter in 201 photographing 31 radio studies of 184, 186

luminosity distribution 201

mass of 193 radio sources in 201, 204 size 201 evolved stars in 193 formation and evolution 214-5 gas in 144-5, 172, 188 giant, elliptical 194, 202, 203 hydrogen content 200, 201 interacting 202, 203 interstellar matter in 200-1 irregular 191 barred 194 classification of **192**, **194** masses of 202 late 193, 200 luminosity of 194, 201 luminosity classification of 194 Markarian (see galaxies, active) masses of 202 most distant known 197 N-type (see galaxies, active) normal 191 nuclei of. black holes in 210 spinars in 211 white holes in 211, 214 photographing 31 radio 190, **201**, 203, 207, 209 et seq in clusters 203 energy sources 210-11 structures 209 et seq 3c 184 : 226-7 radio emission by 201 redshift of 196 et seg relative numbers 194 spiral 191 anaemic 194 arms of 201 barred 192, 193 classification of 192-3 and distance measurements 197 hydrogen content 201 masses 202 numbers in clusters 204 Seyfert 207-8 structure 201 warping of disc 199, 201, 202 stellar types in **200** Galaxy 12, **164** et seq age of 168-9 centre of 165, 168, 170, **188** et age of features 190 central star cluster 189 gas motion within 188-9 mass 189 molecular ring 189 radio sources 189-90 3 kpc arm 188, 189 + 135 km per s feature 188, 189 differential rotation 166 distance scale 173 et seq disc 165, 166, 170, 172 et seq, 188 radio emission from 186 warping of 202 dust within 166, 180 formation of 168 et seq gas within 166, 178 et seq, 186 et seq globular clusters in 170 age of 170 , 'tramp' 170 halo of 168, **170** et seg mass of 172 stars in 170, 172 interaction with Magellanic Clouds 202 magnetic field of 184 et seq mass of I72, 188 models of 164 molecular clouds 180 obscuring matter in 164, 166

rotation of 166, 188, 189

rotation curve 188 size of 12, 164, 169 spiral arms 12, 165, 174, 188 stars in 12, **16**5 et seq populations 166 et seq stellar distribution in 170 et seq . structure of **165** et seq Galilei, Galileo 10, 81, 132 Galileo orbiter (spacecraft) 245 gamma-ray bursters 73 Gamow, George 224, 226 Ganymede 139, 140T gas clouds, interstellar 178 et seq, 185 et seq gegenschein 158 Geminga 72 U Geminorum stars 65 geodesic 221 giant stars **49**, 52T, 62 globular clusters 12, 58 et seq, 171 age of 170 in Galaxy 169, 170 H-R diagram 60 sizes of 170 Gold, Thomas 224 graben 93, 116, 122, 126 gravitational collapse, and black holes 73 et seq and supernovae 64 gravitational constant, possible variation of 227 gravitational contraction 58 and planetary bodies 133, of stars 60 and white dwarfs 64-5, 70 and ultra-dense bodies 67 gravitational deflection of light 221 gravitational lenses **221**, 223 gravitational theory **72** alternative **70**, **91**, **227** Einstein **27**, **220** Newton **26**, **216** gravitons 206 gravity wave detector 244, 246 gravity waves 72 gravity, zero 220 'Great rift' (Cygnus) 166 greenhouse effect 95 Greenwich Mean Time 17 H-R diagram (see Hertzsprung-Russell diagram) H II regions 178 et seq flin external galaxies 197, 200-1 in galactic centre 189 infrared emission 178 et seq intergalactic (dwarf galaxies) 208 Halley, Edmond 12 Hawking Stephen 223, 224 heavy elements: formation 61 et seq, 169 in galaxies 200 in interstellar medium 169 in solar nebula 160 in stars 170 heliosphere 79 helium, abundance 54T in early universe 226 fusion **61**, 62 in planets 133, 140 in stars 61 helium flash 62, **65** Hellas basin (Mars) 125 Herculina and satellite 154 Hercules X-175 Herschel (crater on Mimas) 144 Herschel, Caroline 164 Herschel, Sir William 153, **164**, 176 Herschel wedge 82 Hertzsprung, Ejnar 49 Hertzsprung gap 61 Hertzsprung-Russell diagram brightest stars 51, 52

instability strip 66 main sequence 49 zero-age **61** nearest stars 50, 51, 52 open clusters 60, 173, 174 population numbers 52 zones 49, 50 Hevelius, Johannes 10 Hidalgo 153, 154T high energy astronomy 245 'high velocity stars' 172 highlands on: Mars 124-5 Mercury 120 Moon 104 Himalayas 93, 95 Hipparchus 8 Homunculus nebula 67 Horsehead nebula 180, 187 Hoyle, Sir Fred 224, 227 Hubble, Edwin 191 Hubble classification 191 et seq Hubble's constant 196 et seq and critical density of universe 205-6 and galactic masses 201 value of **196** et seq, 224 variation of **198** Hubble's law 196, 214, 226 Huygens Gap (Saturn's rings) 141 Hyades 47, 49, 58, 174, 221 hydrogen in cometary haloes 156 in external galaxies 200-1 fusion 61 in galaxy 172, 178 et seq in galactic centre 188-9 in halo 172 molecular 146, 180 neutral 186 et seg ionized (see H II regions) in local group 172, 199-200 metallic 133 neutral 186 et seg emission from 186 et seq and mapping external galaxies 200-1 and mapping of galaxy 188, 189 in planetary interiors 133, 140, 146 21-cm line 183, 184, 186 hydroxyl radical, in external galaxies 201 in Galaxy 180, 182T masers 182 hypersensitization (of film emulsion) 31, 177, 213 lapetus 145 Icarus 154 igneous rocks 92 image-enhancement techniques 213, 235 image intensifiers 213 impact cratering 106, 160 on Earth 158, 160 on Mars 124-5, 160 on Mercury 120, 160 on Moon 106-7, 160 on Phobos and Deimos 132 Index catalogue (IC) 191 inertial frames 218 infrared observations 17 of extragalactic objects 191, 199 of galactic objects 180, 184, Infrared Astronomical Satellite (IRAS) 245-6 infrared sources 59, 180 et sea Inghirami (Moon) 108, 109 Innisfree (meteorite) 158, 160 intensity interferometer 232 intercloud medium 186 interferometers optical 232 intensity 232 interferometry optical 232 intensity 232

Michelson 52

at Mount Wilson 232

speckle 52, 68, 233, 234

radio 241-2 aperture synthesis 242 grating 241 long base line 242 Mills Cross 241 very long base-line 242 intergalactic 191 intergalactic matter, between clusters 206 dust 206 ionized gas 206 stars 206 temperature of 206 integrated starlight emission lines in 200 method 200 International Halley Watch 151 International Ultraviolet Explorer (IUE) 188 interstellar absorption 184, 189 diffuse bands 183 dust 184 in galaxies 200-1 in Galaxy 178 et seq molecules 180 et seq distribution 180 et sea emission by 180 in external galaxies 201 and microwave background 207 interstellar reddening 184 invariant interval 218 Io 137 et seq colour 137 composition 139 volcanism 137 ionization 47 ionization front 178 ionosphere (Earth) 79, 98 et seq ionospheric layers 98 ionospheric storms 100 IRC + 10216 : 184 Iris 149 irregular galaxies (see galaxies, irregular) Ishtar Terra (Venus) 122 isostasy 117 isotropy of universe 227 Ithaca Chasma (Tethys) 145 Janus 142 Jordan, Pascual 227 Jupiter 92, 132 et seq, 134 atmosphere 133 et seq aurorae 136 composition of 135, 136 pressure of 136 structure of 136

belts 134 colour 136 composition 133 density 133 gravitational effects 133, 137 Great Red Spot 128, 134-5 interior 133 et seq heat source 133 magnetic field 136-7 observation of 128-9 radiation belt 136 radio emission from 136 rings 137 rotation periods 133-4 satellites 137 et seq, 140T observing 129 temperature 134 of atmosphere 134 of interior 133 zones 134

Kant, Immanuel 164 Kappa Crucis (the Jewel Box) 176 Keenan, P. C. 49 Kellner eyepiece 21 Kelvin, Lord 58 Kelvin-Helmholtz contraction 58 Kelvin-Helmholtz time scale -60 Kelvin temperature scale 47 Kepler, Johannes 10, 26 Kepler's laws **26** et seg Kerr, Roy 224

globular clusters 58, 60, 116

evolutionary tracks 61 giant branch 60, 170