CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information

# Index

$a$ – semimajor axis 58
$A$ – albedo 111, 586
$A_1$ – radial nongravitational force 15
$A_2$ – transverse, in plane, nongravitational force 15
$A_3$ – transverse, out of plane, nongravitational force 15
$A_2$ – effect 239
ablation 595
ablation coefficient 595
  carbonaceous chondrite 521
  cometary matter 521
  ordinary chondrite 521
absolute magnitude 592
accretion 86
  hierarchical 86
activity comets, decrease with distance from Sun
  Halley-type comets 100
  Jupiter-family comets 100
activity curve meteor shower 236, 567
air density at meteor layer 43
airborne astronomy 161
  1899 Leonids 161
  1933 Leonids 162
  1946 Draconids 165
  1972 Draconids 167
  1976 Quadrantids 167
  1998 Leonids 221–227
  1999 Leonids 233–236
  2000 Leonids 240
  2001 Leonids 244
  2002 Leonids 248
airglow 45
albedo ($A$) 16, 586
  comet 16
  dust 33, 37, 135
α-Bootids
  1984 telescopic outburst 199
  predictions 617
α-Capricornids 438
  radiant 439
  twin shower 440
  fragmentation index 444
  meteoroid density 444
  potential parent bodies 448–453
α-Centaurids 347–348
  1980 outburst 348
α-Circinids (1977) 198
  predictions 617
α-Lyncids (1971) 198
  predictions 617
α-Monocerotids 183
  1925 outburst 183
  1935 outburst 183
  1985 outburst 183
  1995 peak rate 188
  1995 activity profile 188
  activity 186
  $\chi$ 186
  dust trail width 188
  lack of sodium 190
  meteoroid density 190
  orbital period 188
  predictions 617
  upper mass cut-off 188
α-Pyxidids (1979) 199
  predictions 617
α-Scorpiids 511
α-Virginids 503
  particle density 503
amorphous water ice 22
Andromedids 153–155, 380–384
  1872 storm 380–384
  1885 storm 380–384
  1899 return 384
  activity 380–384
  discovery 9
  dust trail encounters 667
  mass loss of comet 383
  total mass 383
angular elements 59–60



© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



annual shower 6, 475
  activity throughout year 6, 475
  apparent rate visible to naked eye 475
  $\chi$ 95
  cause of nodal dispersion 307
  definition 475
  different from Filament component 476
  dust distribution in $\Delta r$ 478
  example: Lyrid shower 476
  formation of annual Leonids 476
  how to discover 9–10
  number of showers 475
  Sun's reflex motion 478
  variation of rates during year 6, 475, 497
annual shower background 485
  caused by precession 485
  example: Perseids 485
annual variation of all meteor activity 6, 475, 497
  peaks in fall and summer 499
anomaly (angle from perihelion) 60
  eccentric 60, 61
  mean 61
  true ($v$) 60, 61
antapex direction/source 496
antitail comet 33
antihelion direction/source 110, 496
  caused by Jupiter-family comets 496
  percentage of activity 515
apex direction/source 496
  northern/southern 496, 515
aphelion 36
aphelion distance ($Q$) 59
Apollo-like orbit 496
aqueous alteration of minerals 145
argument of perihelion ($\omega$) 59
asteroid 140–149, 520
  Amor-type orbit 140
  Apollo-type orbit 140, 496
  Aten-type orbit 140
  definition 140, 520
  main belt asteroid 140
  near-Earth asteroid (NEA) 140
  origin 140
  rotation rate 149
  size boundary meteoroids–minor planet 140
  source of meteoroids 520
  source of meteoroid stream 140
asteroid main belt
  relative impact speed among asteroids 148
asteroids – individuals
  (1) Ceres 145
  (433) Eros 146
  (1566) Icarus 397
  (1620) Geographos 527
  (2101) Adonis 449
  (4179) Toutatis 499
  (4450) Pan 505
  (2102) Tantalus 519
  (2212) Hephaistos 509
  (4486) Mithra 509
  (5335) Damocles at Mars 569
  (5496) 361
  (9162) 1987 OA 449
  5025 P-L 463
  1990 SM 509
  1990 $TG_1$ 509
  1993 $KA_2$ 463
  1995 CS 449
  2000 $YP_{29}$ 509
asteroid family 148
  age 149
  colors (taxonomic class) 525
  percentage of all asteroids 149
  relative velocities 149
  size distribution of members 149
asteroidal meteoroids, how to recognize
  deep penetration 520
  early start of ablation 520
  $k$-criterion (ablation heights) 521
  pure iron 520
  Tisserand parameter (orbit) 520
asteroidal meteoroid streams 522
  case of $\delta$-Leonids 528
  case of October 4/5 fireballs 528
  definition 523
  different materials in one stream 526
  H-chondrite stream (exposure ages) 528
  small impacts 146
  stream formation 146
astrobiology 223
astronomical unit (AU) 23
atmosphere 41, 42–45
  ionosphere 43
  thermosphere 43
  mesopause 43
  mesosphere 43
August Capricornids 438, 450
Aurigids 82
  1935 outburst 175
  1986 outburst 175
  1994 outburst 176
  2007 predicted outburst 192
  delta-Aurigids 175
aurora 43

$B$ – exponent of exponential activity curve (~width) 242
$\beta$ – ratio of radiation/gravity forces 33
  definition 33

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



maximum value for small grains 33
typical value for meteoroids in comet tail 33
typical value for meteoroids in dust trail 33
value for meteoroids 540
Baker–Nunn Super–Schmidt camera 165
balloon flight 161
barycenter
definition 179
$\beta$-Aurigids (1968) 197
$\beta$-Canis Minorids (1988) 200
$\beta$-Hydrusids (1985) 346–347
outburst predictions 617
$\beta$-Leonis Minorids (1921) 193
$\beta$-meteoroids (small grains with high $\beta$) 540
impact rate on Venus 565
$\beta$-Perseids (1935) 195
predictions 617
$\beta$-Pictoris source of interstellar meteoroids 560
$\beta$-Tucanids (2003) 85
predictions 617
bolide 3
size boundary with asteroids 140
Bootids (see Quadrantids) 357
breakup (see fragmentation)
broken comet showers, 480

$c$ – speed of light
$c_\odot$ – solar constant 587
$C_d$ – drag coefficient 595
$\chi$ – magnitude distribution index 92
$\chi_f$ – progressive fragmentation index 595
C-H stretch vibration emission 582
calcium–aluminum-rich inclusion 577
calendar 598
Julian 598
Gregorian 598
Canis Majorids (1985) 199
Capricornids (see $\alpha$-Capricornids) 438–442
Capricornids–Sagittariids 442
relationship to $\alpha$-Capricornids 442
carbon (see "CHON")
carbon chain depletion 114
carbonization 107
cardinal directions 496
antapex 496
antihelion 496
apex 496
helion 496
Carinid Complex 516
catastrophic fragmentation
of dust 94
of comets 384
amount of dust generated 384
Centaur (minor planet) 65
number >100 km 65
Centaurid Complex 516
CHON 105
content by weight in comet dust 105
content in IDP 106
origin from irradiated frost 106
origin from condensation of carbon gas 106
chondrules 577
clustering of grains 238
CN production 114, 581
CO in comets 22, 24, 318
driver of outbursts 318
collision between comets 378
explosion 378
relative speed 378
collision cascade 50, 94
color index 592
color of meteors 48
changes 48
coma 32
Comae Berenicids 313
association with comet Lowe 313
comet 12
activity at large distance from Sun 24, 317
antitail 33
brightness versus distance from Sun 95
coma 32
cometesimals 577
definition 140
diameter versus brightness 79
dust tail 32
formation 575
infalling interstellar grains 575
hierarchical accretion 576
pebbles 576
cometesimals 577
gas production rate 79
ion tail 31
mass distribution index 79
size nucleus from activity 79
spectrum 103
striae 35
comet crust
cosmic ray exposure 86
pristine 86, 190
surface 18, 32
comet fragmentation
amount of dust lost in LPC breakup 86
brightening of comet 87
catastrophic disruption 378
different ways 378
collisions 378

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



comet fragmentation (cont.)
spin-up 378
tidal disruption 379
thermal stresses 379
separating fragments 378
spill-off 378
comet model
dirty snowball 15, 165, 261
flying sandbank 14
icy conglomerate 15
icy mudball 261
rubble pile 20, 86
comet nucleus
albedo ($A$) 111
bright spots 18
bulk density 20, 91, 111
examples: Halley 16
extinct 137
fraction surface area active ($f$) 587
ice content 87
magnitude and diameter relationship 137
rapid rotation 111
spin 27
splitting 86
surface stress at equator 111
surface temperature 24
tensile strength 86, 378
comet individual
1P/Halley 14, 91
active area 18, 96
activity versus distance from Sun 26
age 493
albedo 16
associated showers (Orionids, $\eta$-Aquariids) 495
at Mars 569
axis ratio 91
brightness 95
bulk density 20, 91
dust and gas production rate 96
dust experiments 105
ejection of small grains 307
evolving into sungrazing comet 90
jets 18, 96
mass 91
mass loss, function of mass 307
mass lost from surface 495
nongravitational force 96
nucleus 16
orbital evolution 305
possible close approach to Jupiter 493
rotation period 91
size 91
surface temperature 24
water outflow speed 95
2P/Encke 132–135
active area 135
albedo 134, 135
associated showers (Taurids) 133, 457
at Earth's orbit 462
at Mercury 564
brightness with distance from Sun 133
captured in present orbit 455
dust albedo 135
dust ejection speed 134
dust production rate 134
dust size distribution 134
dust trail 29, 133
dust-to-gas ratio 135
dynamically old 127
jets 135
mass of trail 133
nucleus size 134, 135
peculiarities of orbit 130
spin period 135
total dust and gas loss per orbit 134, 135
total mass 134
water production rate 134
width of trail 133
3D/Biela 119–121, 383
association with Andromedids 380–384
diameter 120, 383
dust trail encounters 667
fragmentation 14
mass loss comet 383
moment of breakup 120
relative speed fragments 120
5D/Brorsen 361
6P/d'Arrest 127
possible meteor activity 351
relationship to $\kappa$-Cygnids? 454
7P/Pons–Winnecke 117–119
association to June Bootids 337
brightness 118
diameter 119
dust mass loss per revolution 119–121
dust trail 29
dust trail encounters 671
dynamically old 127
ejection speed 119
gas loss rate 119
IRAS dust trail 119
orbital dynamics 117–119
8P/Tuttle 102–104
association with Ursid shower 263
brightness 102
diameter 102
minimum distance 263
nongravitational force 102

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



comet individual (cont.)
small dust production rate 104
spectrum comet 103
theoretical radiant 263
water evaporation rate 103
water production rate 104
9P/Tempel 1 18
target of Deep Impact mission 18
size 18
10P/Tempel 2 29
IRAS dust trail 29
12P/Pons–Brooks
association with Quadrantids (unlikely) 361
13P/Olbers meteors at Mars 569
14P/Wolf, relationship to Capricornids (unlikely) 448
15P/Finlay 127
future dust trail encounters 675
meteor activity 350
19P/Borrelly 16
active area 18
density 20
jets 18
size 16
spin period 27
target of Deep Space 1 mission 16
21P/Giacobini–Zinner 110–114, 327
albedo 111
association with Draconids 325
axis ratio 110
brightness 113
bulk density 111
carbon chain depletion 114
composition 113
diameter 110
dust density away from nucleus 113
dust trail encounters (Draconid storms) 676
dynamically old 127
large grain ejection speed 113
production of CN 114
rotation period 110
small grain ejection speeds 113
spin axis 111
surface stress at equator 111
tail 113
tensile strength meteoroids 111
vapor outflow speed 113
22P/Kopff
ISO dust trail 38
26P/Grigg–Skjellerup 114–117, 321
active area 116
association with π-Puppids 114, 321
axis ratio 115
diameter 115
dust and gas production rate 116
dust ejection speeds 116
dust trail encounters 680
dynamically old 127
dynamic history 324
large grains near nucleus 117
nongravitational forces 116
rotation period 115
size distribution 116
spin axis orientation 116
38P/Stephan–Oterma
association with Quadrantids (unlikely) 361
41P/Tuttle–Giacobini–Kresák 31, 127, 506
breakup 506
meteor activity (unlikely) 353, 506
45P/Honda–Mrkos–Pajdusáková 127, 449
at Venus 564
dust trail encounters 683
relationship to α-Capricornids (unlikely) 448, 449
future meteor activity 353
46P/Wirtanen 888
future meteor activity 350
55P/Tempel–Tuttle 11
865 AD, first inside Earth's orbit 218
902 AD, first storm 218
1366 close encounter 99
1866-dust trail segment 240
albedo 100
association with Leonids 11
brightness 100
brightness in 1998 208
dust trail formation 36
dust-to-ice ratio 101, 260
detection in space 37
diameter 99
ejection in AD 1333 210
jet 27
mass loss per orbit 101, 260
maximum particle size 27
nearest to Earth in AD 1998 208
nearest to Sun in AD 1998 208
nongravitational parameter 100
nuclear axis ratio 99
recovery in AD 1997 208, 218
shedding of boulders 259
spin period 27, 100
water production rate 100, 260
62P/Tsuchinshan 1 127
possible historic shower 127
67P/Churyumov–Gerasimenko 128
possible future showers 128
72P/Denning–Fujikawa 128
future meteor activity 353
relationship to Capricornids (unlikely) 448
relationship to Sagittariids (unlikely) 513

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



comet individual (cont.)
73P/Schwassmann–Wachmann 3 121–123
1995 breakup 122
associated τ-Herculid shower 391
diameter 123
dust trail encounters 684
orbital dynamics 121–123
possibly dynamically young 127
potential activity from Virgo 395
relative speed of fragments 123
76P/West–Kohoutek–Ikemura
future dust trail encounters 353, 688
79P/du Toit–Hartley 128
potential source of historic showers 128
81P/Wild 2 16
jets 18
size 16
target of Stardust mission 16
96P/Machholz 1 359, 426
Machholz complex showers 425
relation to sunskirting comets 425
103P/Hartley 2 128
diameter 349
ejection speed dust 350
formation temperature of ices 350
future dust trail encounters 688
predictions for future meteor activity 349–350
107P/Wilson–Harrington 136
albedo 137
association with September Sagittariids 136
diameter 136
fading 136
nuclear magnitude 137
rotation period 137
109P/Swift–Tuttle 11, 97–99
AD 188 sighting 284
69 BC sighting 284
1981 predicted return 271
1992 predicted return 274
2126 collision with Earth? 284
association with Perseids 11
brightness 98
diameter 98
dust grain ejection speed 98
dust-to-gas ratio 98
location of active areas 98
nongravitational force 97
position of pole axis 99
rotation period 98, 99
size distribution index 98
141P/Machholz 2 128
relationship to α-Capricornids (unlikely) 452
C/962 $B_1$ 311
possible earlier sighting of C/1854 $L_1$ (Klinkerfues) 311
C/1457 $L_2$ 448
proposed as α-Capricornid parent (unlikely) 448
C/1490 $Y_1$ 361
possibly associated with Quadrantids 361
comet brightness 372
C/1499 $Q_1$ 317
possible earlier sighting of C/1991 $L_3$ (Levy) 317
C/1723 $T_1$ (K.-C.-S.) 85
linked to October Monocerotids 85
C/1739 $K_1$ (Zanotti) 82
diameter 82
likely parent of October Leonis Minorids 82
C/1742 $C_1$ 315
linked to C/1907 $G_1$ (Grigg–Mellish) 315
C/1798 $X_1$ (Bouvard) 73, 84
linked to December Leonis Minorids 84
C/1852 $K_1$ (Chacornac) 84
diameter 84
outburst predictions 617
linked to η-Eridanids 84
C/1854 $L_1$ (Klinkerfues, 1854 III) 311
associated with ε-Eridanids 311
discovery 311
outburst predictions 617
C/1860 $D_1$ (Liais)
association with Quadrantids (unlikely) 361
C/1861 $G_1$ (Thatcher) 80
parent of April Lyrids 11
cause of outbursts 172
diameter 80
C/1862 $N_1$ (Schmidt) 73, 84
linked to historic ζ-Arietids 84
C/1874 $G_1$ (Winnecke) 73, 84
linked to η-Cetids (uncertain) 84
C/1907 $G_1$ (Grigg–Mellish) 315
associated with δ-Pavonids 315
outburst predictions 617
theoretical radiant 315
C/1911 $N_1$ (Kiess) 82
parent of Aurigids 82, 175
C/1917 $F_1$ (Mellish) 104–105
association with December Monocerotids 309
diameter 104
discovery 104
C/1939 $B_1$ (Kozik–Peltier)
linked to Quadrantids (unlikely) 361
C/1943 $W_1$ (V. G.-P.-D.) 73, 84
associated with November Hydrids 84
C/1947 $F_2$ (Becvar) 73, 84
associated with δ-Serpentids 84
C/1964 $N_1$ (Ikeya) 85
linked to ε-Geminids (unlikely) 85
C/1969 $T_1$ (Tago–Sato–Kosaka)
outburst predictions 617

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



comet individual (cont.)
C/1976 $D_1$ (Bradfield)
expected activity from $\beta$-Tucanids 85
outburst predictions 617
C/1983 $H_1$ (IRAS–Araki–Alcock) 73–77
active surface area 76
discovery 73
mass 75
northern pole 75
parent of $\eta$-Lyrids
rate of mass loss 76
rotation period 75
size 74, 75
C/1983 $J_1$ (S.-S.-F.) 80
unlikely source of meteors 80
C/1987 $B_1$ (N.-T.-T.) 85
linked to $\varepsilon$-Geminids (unlikely) 85
C/1991 $L_3$ (Levy) 316
possible source of meteors 316
spin period 316
C/1995 $O_1$ (Hale–Bopp) 18, 25
activity versus $r$ 26
bright comet 18
dust input in zodiacal cloud 544
outflow speed 25
size 18
C/1999 $S_4$ (LINEAR) 86
well observed breakup 86
D/1766 $G_1$ (Helfenzieder) 129, 502
association with $\eta$-Virginids 353, 503
possible breakup 503
D/1770 $L_1$ (Lexell) 99, 125–126
1770 close approach to Earth 126
association with $\mu$-Sagittariids 126, 513
D/1783 $W_1$ (Pigott)
association with Quadrantids (unlikely) 361
D/1819 $W_1$ (Blanpain) 123–124
diameter 124
dust trail encounters 690
mass loss rate per orbit 124
parent of Phoenicid shower 123
possibly dynamically young 127
potential storm from Gruis 124
D/1892 $T_1$ (Barnard 3) 129
association with Quadrantids (unlikely) 361
D/1978 $R_1$ (Haneda–Campos) 124, 345
parent of October Capricornids 345–346
diameter 124
D/1993 $F_2$ (Schoemaker–Levy 9) 380, 571
relative speed fragments 380
secondary fragmentation 380
size distribution grains 380
example of tidal breakup 380
P/1999 $RQ_{28}$ (LONEOS) 128
possible source of historic showers 128
P/2000 $G_1$ (LINEAR) 128
possible source of Daytime Lepusids 128
P/2001 $Q_2$ (Petriew) 128, 349
possible source of $\beta$-Cygnids 128
P/2003 $K_2$ (Christensen) 129
possible source of future showers 129
P/2004 CB (LINEAR) 129
2014 meteors 352, 689
brightness 352
future dust trail encounters 689
P/2004 $R_1$ (McNaught) 129
possible source of future showers 129
1913 I (Lowe) 313
uncertain comet, linked to Comae Berenicids 313
1750 (Wargentin) 314
badly observed, linked to Comae Berenicids 314
cometesimal 20
Corvid shower 136, 163
discovery 395
Giordano Bruno impact crater 395
parent 395
relation to comet 11P 395
relation to comet 107P 395
counting meteors in bins 253
crevasse 21
Crifo ejection model 586
cross section dust trail 236
cross sectional area dust 92
crystallization 22
CS 75
cut-off, upper mass limit 188
Cyclids 542

$d$ – diameter dust grain
$D_c$ – diameter comet 79
$\Delta a_0$ – initial change in semimajor axis 252
$\Delta r$ – miss-distance 252
$\Delta\Omega$ – shift in node
$D$-criterion 480, 596–597
$D_{SH}$-criterion 480, 596–597
Daytime Arietids 428
discovery 428
evolution cycle 435
relationship to Marsden group 427–430
stratified structure 429
daytime showers 167
discovery 428
December Leonis Minorids 84
December Monocerotids 309–311
association with parent comet 309
fireballs in Middle Ages 309, 310

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



December Monocerotids (cont.)
peak rate 309
radiant 309
unlikely link to 3200 Phaethon 309
declination 41
decoupled from Jupiter 130
δ-Aquariids 430–432
activity as function of magnitude 432
evolution cycle 435
fragmentation index 437
magnitude distribution index 432
meteoroid density 437
northern δ-Aquariids 435
rates 7
relation to Machholz complex 430
southern δ-Aquariids 431
stratified structure 432
δ-Pavonids 315
link to comet Grigg–Mellish 315
δ-Piscids 200
δ-Serpentids 84
density comet 20, 91
density meteoroid 76, 237
carbonaceous chondrite 521
CV 522
CM 522
CI 522
cometary matter 521
freshly ejected cometary matter 521
interplanetary dust particle 105
Leonid dust 237, 257
ordinary chondrite 521
direct association 481
distorted trails 321
dormant comet nucleus (see: extinct comet) 137
Draconids 325
1926 outburst 163
1933 storm 163
cause 228
1946 storm 165, 325
cause 228
1952 outburst 327
1953 return 327
1972 outburst 167, 327
1985 outburst 327
activity curve 327
1986 outburst 327
1988 predicted return 330
1998 outburst 330
activity profile 333
mean radiant 332
peak rate 331
prediction 230
1999 return 333
2011 return predictions 334
beginning heights 332
dust trail encounters 676
elemental abundance 328
meteoroid density 328
meteoroid fragmentation index 328
tensile strength meteoroids 111, 328
drag coefficient 595
dust
albedo 37
density 76, 237
equal cross section per interval 92
equal mass in each mass interval 92
thermal emission 28
dust mantle comet 76
dust number density
decay with distance from comet 76, 95
dust tail 32
dust trail 28
calculate total mass in trail 259
dimensions 29
discovery 28
distribution of dust in trail 232, 250
dust density 29
evolution 38
final position of particles 36
formation mechanism 35
illustration 36
inward leg 36, 191
motion near-Earth's orbit 180
particle sizes 37
perpendicular spreading 38
visible in scattered sunlight 38
dust trail distribution in node $\Delta\Omega$ 237
broadening with time 41, 249
calculated distribution 255
change by planetary perturbations 324
cross section 236
intrinsic width 237, 242
offset center Leonids 237, 242
variation with miss distance 241
width 41, 237
dust trail distribution in orbit $\Delta a_0$ 232, 237
evolution along the trail 190
gap 232
offset from comet position 237
peak of dust density 255
range in orbital periods 35
spreading by planetary perturbations 321
tail in distribution 253
width 237
dust trail distribution in distance Sun $\Delta r$ 242, 252
change by planetary perturbations 324
discrepancies 253

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



distribution 253
offset from calculated 253
outward tail 255
dust trail distribution of meteoroid size 257
change along dust trail 259
presence of large masses 257
typical value Leonid trails 257
upper-mass cut-off 188
dust trail stages of evolution
delay of orbital period 228, 229
distortions from planetary perturbations 321
Filament 192
formation 35
dust trail from fragmentation 380
dust-to-ice ratio in comets
long period comets 87
Halley-type comets 98, 101, 260
Encke-type comets 135

*e* – eccentricity 59
*E* – energy 589
ε – material emissivity 587
Earth
reflex motion 180
speed in orbit 4
eccentric anomaly 60
eccentricity (*e*) 59
ecliptic plane 58
ecliptic shower 496
ecliptic showers – individual
ρ-Geminids 504
δ-Cancrids 505
δ-Leonids 505
α-Virginids 503
η-Virginids 506
ν-Hydrids 507
α-Leonids 507
λ-Virginids 508
Librids 508
μ-Virginid 508
γ-Librids 508
δ-Librids 508
May λ-Virginids 508
α-Scorpiids 511
ω-Scorpiids 513
μ-Sagittariids 513
σ-Sagittariids 513
κ-Aquariids 514
ecliptic streams
point of closest approach 324
typical impact speed Earth 110
Edgeworth–Kuiper Belt 62
ejection of dust
angle of ejection 250
coupling to gas flow 586
delay of orbital period 228, 229
ejection speed 94
initial acceleration 26
maximum size 27
position in comet orbit ($\Delta a_0$) 250
stress after ejection 26
ejection of meteoroids
by breakup of comets 378
collision cascade fragmentation of grains 259
Whipple-type water vapor drag 585
ejection of comets
during formation 87
ejection speed 94
at perihelion 239
for correct return time 229
for grains arriving at Earth 250
for Halley-type comets 239
for Jupiter-family comets 116, 119, 350
for Encke 134
Whipple ejection speed 585
electron 43
ellipse 58
ellipsoidal shaped meteoroids 94
emission from meteors
atomic lines 48
dependence on speed and mass 48
mechanisms 49–57
molecular bands 48
Encke-type comets 130
time until dormancy 130
energy
conservation law 45
kinetic energy 40, 45
potential energy 40, 41
total energy 40
epoch
ε-Eridanids
1981 outburst 311
annual activity 311
association to Klinkerfues 311
outburst predictions 617
possible historic outbursts 314
possible recent outbursts 315
ε-Geminids 85
equinox 59, 159
escape speed 569
η-Aquariids 303
activity profile 306
AD 585 shower 309
AD 930 shower 309
age 495
discovery 304
dust trail encounters 308

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



$\eta$-Aquariids (cont.)
ejection speed from Halley 94
formation history 490
origin 91
no enhanced rate return Halley 304
magnitude distribution index 92
miss-distance 304
rates 7
$\eta$-Eridanids 85
$\eta$-Lyrids 77
$\eta$-Virginids 506
1953 possible outburst 506
evaporation 49
exponential component ($B$) 242
extinct comet nucleus 137
dynamical lifetime 139
most likely associated with showers 612
nomenclature 368
number in inner solar system 138
percentage of time dormant 138
extinct comets (judging from meteoroid stream association)
individual cases
1979 VA (Wilson–Harrington) 615
possible association with September Sagittariids 514, 615
1983 LC 514
possible source of November Scorpiids 514
1983 TB = 3200 Phaethon 139, 397
parent of Geminids 397
diameter 139
geometric albedo 139
mythology 397
rotation period 139
surface melting 139
taxonomic class 139
1986 JK (14827 Hypnos) 514
possible source of August Virginids 514
1996 $AJ_1$ 508
just perhaps associated with $\lambda$-Virginids 508
1998 $HJ_3$ 508
just perhaps related to May Virginids 508
1998 $SH_2$ 508, 613
possible association with $\alpha$-Virginids 508, 613
1998 $SY_{14}$ 514
possible source of October Aquariids 514
1998 KM 513
just perhaps associated with $\alpha$-Scorpiids 513
1999 $RD_{32}$ 505
possible association with $\delta$-Leonids 505
1999 $RM_{45}$ 507
possibly associated with $\nu$-Hydrids 507
2000 $DK_{79}$ 519
unlikely association with Puppids-Velids 519
2000 $QS_7$ 513
potential source of late Capricornids 513
potential source of autumn Ophiuchids 514
2001 HA 514
possible source of $\beta$-Cetids 514
2001 $ME_1$ 612
Daytime Capricornids-Sagittariids 612
possibly associated with N. $\sigma$-Sagittariids 513, 614
2002 FC 613
N. $\gamma$-Virginids 613
2002 $EX_{12}$ 450
relationship to Capricornids 453
2002 $GM_5$ 508
just perhaps associated with Virginids 508
2003 $BK_{47}$ 513
potential source of $\beta$-Cygnids 513
2003 $EH_1$ 377, 612
association with C/1490 $Y_1$ 371
best possible common orbit 376
diameter 371
orbit 368
parent of Quadrantids 368
2003 $WY_{25}$ 377, 384, 616
parent of Phoenicids 616
2003 $YG_{118}$ 507
possibly associated with N. $\nu$-Leonids 507
2004 $BZ_{74}$ 613
possible association with $\alpha$-Scorpiids 511, 613
2004 HW 395, 613
association with Corvids 613
2004 $JR_1$
relation to $\kappa$-Cygnids? 454
2004 $NL_8$ 514
associated with $\kappa$-Aquariids 514
2004 $TG_{10}$ 470
parent of Taurids 378, 470
2005 UB 399, 544, 566
parent of Sextantids 399

$f$ – fraction of surface area active 587
$f_m$ – mean anomaly factor 232, 251
$\phi$ – angle in elevation 589
F-Corona 541
inner edge of meteoroid survival 541
smallest perihelion distance streams 541
fading problem of long-period comets 71
mean survival 72
falling star 3
fallen back meteoroids 32
Filament 192
AD 608 ejecta 212
1366: required ejection speed 210
after comet return 249
cause 210–215

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



cause of onset of activity 214
dispersion 212
epoch of ejection 211, 212
Leonid 202, 207
Leonids, data and forecast 619
Perseids 295
Perseid dispersion of radiants 295
response to Sun's reflex motion 214
role of 1366-dust trail 210
spreading dilemma 214
trails catch up on each other 192
trapping in mean motion resonances 214
typical diameter 192
Ursids 263–265
fireball 3
flux of light 592
forecasting meteor storms
activity of the shower 231, 250
peak time 158
forward meteor scatter
Global-MS-Net 201, 303, 342, 511
Intern. Project for Radio Meteor Observations 468
Radio Meteor Observers Bulletin 201
fragmentation
1835 breakup of 3D 119–121
1995 breakup of 73P 122
attogram grains 26
in interplanetary medium 238
in comet coma 238
index 307, 406
meteoroids after ejection 26
of boulders 238
relative speed fragments 120, 123
fragmentation mechanisms comets
collisions 378
spin-up 378
position primary component 378
relative speed fragments 378
threshold spin period 378
thermal stresses 379
tidal disruption 379
binding energy 378
separation velocity 379
FWHM (full-width-at-half-maximum) 21

$g$ – gravitational acceleration at Earth's surface
G – gravitational constant 587
$\gamma$-Delphinids (1930) 194
predictions 617
gaps in dust trail 232
gas production rate
function of comet volume 79
Gauss method 156
Gegenschein 544
Geminids 402
age 408, 412
activity 7, 402
background component 405, 422
change over the years 400
main peak 405
variation along orbit 402
change of node over the years 400, 410
change in orbital elements over time 422
angular elements 420
semimajor axis 419
discovery 400
discrete breakup 420
fragmentation index 406
future activity 422
meteoroid density 406
meteoroid tensile strength 328, 407
orbit evolution 408
total mass 406
visual observations 414
width of the shower 411
variation with time 412
geocentric (from perspective of Earth)
velocity 40
radiant 41
Giant Comet Hypothesis (Taurid Complex) 455, 470
size of proposed comet 455
size accounted for 470
time of breakup 471
giant planet region of comet formation 85, 86
Glanerbrug meteorite 526, 527
glass transition in water ice 22
gnomonic star chart 9
gravitation 14
gravity waves in atmosphere 57
grazing meteors 176
Gregorian calendar 598
Grün model of dust impacts on Earth 556

$h$ – angular momentum 589
$H$ – altitude above Earth's surface 590
Halley-type comets 88
circumstances of formation 105–107, 106
number in inner solar system 88
physical lifetime 90
properties of dust 105–107, 106
halo and "shock" 246
hard bit 107
Harvard Meteor Program 165, 413, 419, 438, 480, 484, 515
Dona Ana location 390
Soledad Canyon location 390
heat
fraction going into sublimation 587
latent heat of sublimation 587

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



heliocentric distance ($r$) = distance from Sun 22
  onset meteoroid stream formation 110
helion source 110, 496
Hephaistos group 509–510
Hirayama asteroid family 148, 533
  age 149
  percentage of all asteroids 149
  relation to zodiacal dust bands 533
  relative velocities 149
  size distribution of members 149, 619
  Veritas family 533
history of meteor astronomy
  China 6
  Mesopotamia 6
  meteor storm predictions 228
  rates in Middle Ages 6
  records of meteor outbursts 6, 598
hui 12
hydrogen emission in meteors 581
hyperbolic tangent 594

$i$ – inclination 59
IAU Photographic Meteor Orbit Database 439
ice of comets 22
  composition 22
  formation temperature 350, 577
impact
  frequency 531
  of 10 km sized minor planet 547
    example: demise of the dinosaurs 531
  of 1 km sized minor planets 550
    example: Indochina tektite field 550
    danger of dying 550
  of tens of meters in size 552
    example: Tunguska explosion 552
    impact frequency 552
    superbolides 552
impact crater
  comet 20
  moons of Jupiter 551
  population size index 551
  record on Moon 551
impact flashes 238, 562
  1999 Leonid storm 562
  luminous efficiency 562
  meteoroid impact gardening 563
  on Moon 238
  peak impact speed Moon 563
  rate of impacts on Moon 562
impact gardening 563
impact hazard comets 285
  cause of changing impact rates 551
  impact rate on Jupiter 550
  influx on Earth 552
    as function of mass 551
    as function of number 550
  long period comets 71, 179
  meteor showers as early warning 550, 551
  number of impacting NEOs 550
  Space Guard project 550
impact hazard of meteoroids to satellites 45, 216–220
  damage (size dependence) 557
  damage (speed dependence)
    penetration depth 557
    charge production 557
    plasma current 557
  distribution of impact speeds 559
  influx on Earth 552
    as function of mass 551
    as function of number 550
  range of sizes where meteoroids dominate 554
    low Earth's orbit (LEO) 554
    geostationary orbit (GEO) 554
  situation during 1966 Leonid storm 554
  space shuttle 45
  speed distribution of meteoroids hitting Earth 559
  speed of meteoroids hitting Earth
  testimony US Congress 216
  total surface area for all satellites 555
  typical size for peak of mass influx 552
impact on asteroids
  dust size distribution 146
  escape speed 146
  fragments 147
  Hirayama asteroid families 148
  mass distribution in small collisions 147
  mutual collisions 148
  total ejected mass from gravel 146
inclination 59
influx of matter on Earth 552
  as function of mass 551
  as function of number 550
  Divine model 557
  Grün model 556
  Jenniskens and McBride model 557
  total mass 552
  typical grain size at peak of mass influx 552
Innisfree meteorite 524
integration program for orbits 229
intermediate long-period comets 71
interplanetary dust particles 105, 553
  carbon content 106
  density 105
  elemental composition 106
  GEMS 106
  solar wind tracks 541
interplanetary cloud (see zodiacal cloud)

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



intersect Earth's orbit 62
interstellar meteoroid 559
  apparent impact speeds 559
interstellar meteoroid streams 559
ion 43
ion tail comet 18
$\iota$-Aquariids 437
  meteoroid density 437
  N. $\iota$-Aquariids 437
  S. $\iota$-Aquariids 437
$\iota$-Draconids (see June Bootids)

J – Joule, unit of energy
jet, potential causes 18
  crevasse 21
  exposed ice 18
  landslide 18
  opening angle dust 21
  opening angle gas 21
  seep 21
  sink holes 19
  subterranean cavern 19
Julian calendar 598
June Arietids 167
June Bootids 334–344
  1916 $\iota$-Draconids 334
    historic significance 335
  1921 return 336
  1922 return 336
  1927 return 336
  1998 outburst 336–339
    activity curve 337
    $\chi$ 337
    radiant 336
    source 337
  2004 outburst 339–344
    $\chi$ 342
    dynamic evolution 340
    time of ejection 340
    predicted peak 339
    spectrum 342
  association parent comet 335
  dust trail encounters 671
  mean-motion resonance 339
  meteoroid tensile strength 337
  past returns 344
  predictions 344
June Lyrids (1966) 196
Jupiter 155
  dark spots 572
  global influx of meteoroids 570
  impact rate of comets 550, 572
  impacts on Moons 572
  meteor showers on Jupiter 757
  orbital period 155
  peak impact speed 571
  relative speed with comet 109
  semimajor axis 109, 155
Jupiter's Moons
  impacts 572
  Io's atmosphere 573
  meteor showers 757
Jupiter-family comet 108
  definition 108
  dust trail encounters 321
  dust trail perturbations 321
  dynamical lifetime 110
  dynamically young 126
  fate of orbital evolution 110
  kernel of original nucleus 126
  number in inner solar system 108
  rate of decay 110
  reflex motion 179
  typical grain size ejected 126
  typical impact speed Earth 110

$k_b$ – Boltzmann constant 586
$k$-criterion (meteoroid nature) 521
  Group I (stony asteroidal) 521
  Group II (carbonaceous asteroidal) 521
  Group IIIA (cometary) 521
  Group IIIB (fresh cometary) 521
$\kappa$-Cygnids 442–448
  1993 outburst 445
  fragmentation index 444
  fireballs 444
  meteoroid density 444
  range of semimajor axis 446
  two components 446
$\kappa$-Pavonids 181, 346
  outburst predictions 617
Kuiper Belt 62, 62–65
  Classical 64
  outer edge 64
  Plutinos 63
  scattered Disk 64
Kuiper Belt Object (KBO) 62
  number > 100 km 63
  number > 1 km 63
  size distribution index 63

$\lambda_\odot$ – solar longitude 158
$\Lambda$ – fraction of heat that goes into sublimation 587
$L_1$-libration point 555
$L_s$ = latent heat of sublimation 587
Laplace's formula 155
Leonis Minorids 82

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



Leonid MAC 167, 171, 222, 233–236, 244, 465, 562
  Astrobiology mission 223, 580
  constant nature of plasma temperature 581
  fate of organics 581
  discovery meteor halo phenomenon 53
  detection of meteoric glow in space 37
  first mid-IR spectra persistent trains 582
  luminous mechanism persistent trains 56
  origin of life 580
  rare Taurid fireball video 465
  use of lidar to weigh meteor 46, 204
Leonid Filament
  data 619
  forecast 619
Leonids
  902 storm 218, 261
  1771 storm 8, 262
  1799 storm 8, 262
  1833 storm 8
  1899 outburst 155–160, 228
    lack of storm 261
  1933 outburst 162
  1961 outburst 201
  1965 outburst
    meteoroid density 208
    radiant 207
  1966 storm 220
    peak rate 220, 253
  1969 outburst
    size distribution 259
  1994 outburst 201
    peak rate 202
  1995 outburst 203
    peak rate 203
    radiant 210
  1996 outburst 203
    peak rate 203
  1997 outburst 205
    predictions 216–218
  1998 Filament outburst 210, 221–227
    1899-dust encounter 225, 253
    fireball shower 224
    peak time 210
    predictions 216–220
    radiant 210
  1999 storm
    1866-dust 239
    prediction 230
    width of 1866-dust 239
  2000 outbursts
    1932-dust trail 259
    predictions 240
    width varies with miss distance 241
  2001 storms 242–248
    1767-dust trail encounter 246, 253
    news story of the year 246
  2002 storms 248–250
    background of activity 249
  brightest fireballs 27, 238
  future dust trail encounters 619
  historic storms, position comet 219, 619
  parent comet 11
  rates 7
  Sun's reflex motion 220
length of perihelion (Π) 60
libration
  about mean motion resonance 90
lidar 46
lifetime against collisions zodiacal cloud 539
light of a meteor 49–57
lightcurve 15
long-period comet 71
  crust 86
  ejection of grains in bound orbits 190
  fading problem 71
  grain size ejected 126
  impact rate on Earth 71
  intermediate long period comet 71
  magnitude distribution index 71, 79
  mass distribution index 71, 79
  mean survival time 72
  minimum distance to Earth 72
  number of comets
    associated with streams 72
    in inner solar system 71
    in Oort cloud 71
  orbital period 73
  region of formation 85
  time before breakup 72
long-period comet dust trail 192
  follow Sun's reflex motion 192
  outburst predictions 617
  phase lag 192
  position at Earth's orbit 192
longitude of the ascending node 59
Lost City meteorite 524
Lorentz profile 236
luminous efficiency (τ) 46, 593
  average 594
  differential 594
  intrinsic 594
lunar transient phenomena (see: Moon impacts) 562
Lyrids 80
  687 BC outburst 6, 11
  1803 outburst 10
  1945 outburst 174
  1982 outburst 173

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



annual shower 172, 476
activity 7, 173
cause of outbursts 172
discovery 9
magnitude distribution 172
meteoroid density 172
outburst predictions 617
parent comet 11

$m$ – magnitude of meteor, 488–492
$M$ – mass of meteoroid, 488–492
$M_{\odot}$ – mass of Sun 588
$M_c$ – mass of comet 590
Machholz complex 425
close encounter in 1059 AD 435
$\delta$-Aquariids evolutionary stage 435
Kracht group evolutionary stage 435
Marsden group evolutionary stage 435
magnetic forces on dust grains 538
magnitude scale
absolute 592
definition 591
magnitude of a meteor ($m$) 46
relation to mass 92
magnitude distribution index ($\chi$) 92
annual showers 95
function of mass in trails 259
long period comets 71
meteor storms 95
sporadic background 95
Mars
altitude of meteors 569
entry speed 569
first meteorite found on Mars surface 570
Halley at Mars 569
layer of exogenous matter from meteoroids 569
Martian atmosphere 569
meteor rate 569
meteor showers 568, 756
Marsden group of sunskirting comets 427
date of passing by Earth 427
miss-distance 427
relationship to Daytime Arietids 427–430
short orbital period 427
mass of a meteor ($M$) 46, 488–492
measurement by lidar 46
mass distribution index (s) 92
definition 92
long period comets 71
same amount in each interval 92
mass influx curve
different orbits on low-end size peak 553
explanation of meteoroids mass peak 553
mean anomaly 61
mean anomaly factor ($f_m$) 232, 251
mean motion resonance 89
corresponding semimajor axis 210
evidence from trapped Ursids 266
meetings dedicated to Leonid showers
1998 Meteoroid satellite threat 207, 223
1998 Leonid MAC workshop 207
2000 Leonid MAC workshop 244
2002 Leonid MAC workshop 248
Mercury impact flashes 564
meteoroids from 2P/Encke 564
peak impact speed 564
meteor
beginning height 39
cluster 540
emission spectrum 48
end height 39
light curve 53, 328
meteor emission mechanism
ablation vapor cloud 50
afterglow 55
average luminous efficiencies 594
cascade phase 51
collision cascade 50
differential luminous efficiency 594
duration 593
expansion phase 51
flare 54
forbidden green line 56
halo 53, 246
hot component 51
persistent train 56
rapid evaporation 50
recombination line emission 55
sputtering 50
V-shaped glow 50
warm component 51
meteor gas flow conditions
rarefied flow 50
continuum flow 50
shock wave 50
meteor lightcurve
early peak 328
meteor outburst 6, 282
$\alpha$-Monocerotids 29
Aurigids 29
$\beta$-Hydrusids 29
$\kappa$-Pavonids 29
October Draconids 29
Ursids 29
meteor shower 4, 8
association with comets 10–11
duration 41
on other planets 561

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



meteor sounds
  electrophonic sounds 51
  shock wave 50
meteor storm
  1899 Leonids 155–160
  1095 April storm 4
  duration 41
  first successful prediction 153
  magnitude distribution index 95
meteoric glow 37
meteorite 49, 145, 520
  carbonaceous chondrite 521
    ablation coefficient 521
    density 521
  crust 49
  micro- 50
  ordinary chondrite
    ablation coefficient 521
    density 521
meteoroid 8
  Calcium–Aluminium-rich
      Inclusion 577
  chondrule 577
  cometary
    density 521
    ablation coefficient 521
  coupling with gas 25
  ejection speed 25
  fractal dimension 576
  fragmentation 53
    relative speed of fragments 540
  formation (sequential): 575
    interstellar grains 575
    hierarchical accretion 576
    aggregate particles 576
    aggregates 576
    pebbles 576
    cometesimals 577
  mass, relation to $\beta$ 33
  orbit 58
meteoroid ejection mechanism 14
  Crifo ejection model 25
  Whipple equation 25
meteoroid model
  dust ball 54, 328
meteoroid stream 4
micrometeorite 553
  chemical diversity 553
  from collection in atmosphere 105
  from deep sea sediments 553
  from melt water lake 553
Minor Planet Center 191
minor planet nomenclature 368
miss distance comets 72
Moon impact flashes 561, 562
  1999 Leonid storm 562
  impact speed 563
  viewing conditions 754
Moon sodium atmosphere 561
  impact gardening 563
  Moon's tail (1998 Leonids) 564
  photon sputtering 563
  solar wind 563
  thermal desorption 563
$\mu$-Arietids 200
$\mu$-Pegasids 389
mythology 3

N – number
naked eye sensitivity to light 592
near-Earth asteroid (NEA) 140
  Amor type 140
  Apollo type 140
  Aten type 140
Near-Earth object (NEO) 550
  number with $D > 1$ km 550
Neptune
  impact speed 573
  meteor showers on Neptune 573, 758
  reflex motion 180
  zone of influence 155
Neuschwanstein 524
neutral atom debris layer 561
news story of the year 246
night vision, adaptation 201
noctilucent cloud 45
nodal line 59
nodal miss distance 61
nomenclature
  of meteor showers 78
  of minor planets 368
nongravitational
  acceleration 15
  explanation 165
  force 15, 96
northern branch 131
November Hydrids 84
nucleus (see: comet nucleus) 15
nutation cycle (rotation of nodal line) 130
  Machholz Complex 426
  multiple cycles 485
  Orionids/$\eta$-Aquariids 490
  Quadrantids 357
  Taurids 456

$\Omega$ – longitude of the ascending node 59
$\omega$ – argument of perihelion 59
obliquity 75

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



observing conditions (visual) 202
October 4/5 shower 528
October Capricornids 345–346
  parent comet 345
October Monocerotids 85
$\omega$-Orionids (1964)
  outburst predictions 617
$\omega$-Cetids 435
one-revolution trail (see dust trail)
  total amount of dust 259
onset water vapor production 110
Oort cloud 65, 65–67
  aphelion distance 65
  erosion (sending comets our way) 551
    galactic tide 551
    orbits of Sun around center 551
    motion in and out of plane 551
    molecular clouds 551
    star systems 551
    most recent star encounter 552
    nearest supernova remnant 552
    supernova explosions 552
  extent 65
  formation 66
  origin 66
  Sedna 65
orange arc emission persistent trains 205
orbit 58
  distribution in zodiacal cloud 541
  integration program 229
orbital debris 553
orbital elements 58–60
orbital evolution
  towards avoidance of dangerous ω 132
orbital period ($P$) 59
  long period comets 71
  ILPC 71
  delay from radiation pressure 228
Organizations
  ALPO – Meteor Section 176, 562
  American Meteor Society 159, 173, 196, 220, 274, 384, 406, 505
  Arbeitskreis Meteore 170
  ASSA – Meteor Section 181, 199, 304
  BAA – Meteor Section 163, 198, 273, 274, 387
  British Meteor Society 266, 274
  California Meteor Society 203, 265, 287, 337
  Dutch Meteor Society 28, 82, 168, 196, 199, 203, 223, 234, 248, 263, 268, 286, 301, 391, 415, 419, 470, 495, 504, 524, 527, 593
  FEMA 169
  Fremont Peak Observatory Assoc. 86
  Hawaiian Meteor Society 181
  International Meteor Organization 169, 239, 253, 274, 304
  Italian Meteor Association 304
  Japanese Fireball Network 276
  Minor Planet Center of IAU 191
  MMETH 175
  NAPO – Meteor Section 315
  Nippon Meteor Society 268, 275, 376, 468
  North American Meteor Network 176
  NAS – Meteor Section 267
  NVVS – Meteor Section 280
  Royal Astronomical Society 274
  San Jose Astronomical Association 171
  Shinshu University Astro O.B. Club 275
  SOMYCE 184, 201, 234, 248
  SOVAFA 200
  WAMS 345, 346, 348
  Werkgroep Meteoren van de VVS 170
organic matter 575
  atomic hydrogen from carbonization 581
  chemically induced from atmosphere by meteors 575
  C-H stretch vibration emission 582
  CN emission 581
  comet dust 105, 582
  content by weight comet dust 105
  delivery to Earth 575
  fate in meteoric ablation 581
  Leonid meteoroids 236
  lack of CN in meteors 236
  locked in larger grains 114
  OH radicals and hydrogen atoms 581
origin of life 578
  chemistry during meteor phase 579
  exogenous delivery 579
  Hadean 578
  meteor rate at time 578
  nature of early life 578
  source of organics and water 579
  role of meteors 578
Orionids 301
  1993 outburst 301
  activity is stable 303
  age 495
  annual shower peak 301
  discovery 9
  meteoroid density 20
  origin 91
  ejection speed from Halley 94
  formation history 490
  long-term orbital evolution 490
  mass distribution index 94
  meteoroid density 307
  meteoroid distribution versus Halley 307
  miss distance 301, 490
  outburst, mass distribution index 94
  radiant structure 493

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



Orionids (cont.)
rates 7, 301
Ribbon/Shell Model 303, 492
secondary peaks 493
volume of stream 492
outflow speed from comet nucleus
coupling of dust and gas 586
of dust (see: dust ejection) 92
of water vapor 95
overdense echoes 427

*P* – orbital period 59
$\pi$ – pi = 3.1415
$\Pi$ – longitude of perihelion 60
panchromatic 592
parabolic orbits 14
perception 202
perihelion
preferred site for ejection 239
perihelion distance (*q*) 58
smallest perihelion distance streams 541
Perseids 271
1862 outburst 284
1863 outburst 284
1979 Perseid dust trails 272
1980 Perseids 271
1981 predicted return of 109P 271
1981 postdicted outburst 273
1991 outburst 275
1992 outburst 279–284
1993 outburst 284–286, 659
activity profile 295
dispersion of radiants 295
predicted $\chi$ 294
predicted rates 292
1994 outburst 288
prediction 287
1997 outburst 295
2004 outburst 296
age of annual shower 479
Filament 299
loss mechanism 479
discovery 9
dust trail model 290–295
dust trail predictions 649
early stream model 158
Filament predictions 284–286, 659
historic dust trails 649
historic Filament observations 284–286, 659
Filament 295
meteoroid tensile strength 328
outbursts 1989–1997 271
parent comet 11
periodicity of rates 299
radiant 271
rates 7
Sun's reflex motion 294
total amount of mass 298
persistent trains 57, 288
buoyancy 57
FeO 56, 205
gravity waves 57
luminous mechanism 205
sodium 56
two parallel lanes 57
personal perception 202
Phoenicids 387
1956 outburst 387
1972 outburst 388
annual shower 388
association with comet 385
association with $\mu$-Pegasids 389
photographed meteor
DMS program for multistation photography 168
first 155
Harvard meteor Program 165
photographic fireball network
European Network 168, 466, 495, 524, 529
Meteorite Orbit and Recovery Project 168, 406, 413, 484, 522, 524
Prairie Network 166, 522, 524
physical properties of minor bodies, data 463
$\pi$-Cetids (1977) 199
$\pi$-Puppids 321
1878-dust trail 321
1848-dust trail 321
broadening of trail 323
change distribution of nodes 324
discovery 114
dust ejection at comet 116
dust trail encounters 680
dust size distribution at comet 116
ejection epoch
effect on radiant 324
Gauss' method 156
large grains near comet nucleus 117
merging into zodiacal cloud 533
meteor properties 324
planetary perturbations 14, 155
relative importance of the planets 155
Roche lobe radius 156
zone of influence 155
spreading along orbit 321
trapping in mean motion resonances 321
Plutinos 63
Pluto 63
escape speed 574
impact speed 574

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



meteors on pluto 573
Pluto as a comet 63
Poynting-Robertson drag 480, 536
change of orbital elements over time 536
expected dust density inside source region 536
prebiotic compounds (see: organic matter)
precession
Earth's spin axis 10
function of orbital period 490
meteoroid orbit 11, 60, 133, 408, 485
predicting meteor storms 153
time of maximum 158
Pribram meteorite 523, 524
primary component in breakup 378
pristine comet crust 190
progressive fragmentation index ($\chi_f$) 307
prograde orbit 88
progressive search 481
Puppid-Velid Complex 516–519
Puppid-Velid I Complex 516, 518
Puppid-Velid II Complex 516

$q$ – perihelion distance (AU) 58
$Q$ – aphelion distance (AU) 59
$Q_{H_2O}$ – gas production rate 587
$Q_{pr}$ – radiation pressure efficiency 33, 588
$\theta$ – angle in azimuth 589
Quadrantids 357–375
1976 airborne expedition 167
activity curve 7, 362
background component 362
activity over the years 362
association with C/1490 $Y_1$ 371
discovery 8, 357
dispersion of aphelion 364
from photographed orbits 366
effect of Jupiter on broadening 361
evolution of the node 362
explanation for yearly variability rates 376
nutation cycle 357
magnitude distribution index 362
mass of stream 366
mean density meteoroids 367
meteoroid penetration depth 371
orbital evolution 357
parent body identification 368
radiant dispersion 364
unusual sighting 200

$r$ = distance from the Sun (AU) 22
$R_E$ = radius Earth 591
$\rho$ = meteoroid density
$\rho_c$ = density comet

radar 167
1946 Draconid storm 167
echo height ceiling 53, 542
meteor head echo 53
observational biases 168
overdense echoes 427
underdense echoes 427
radar installations
Adelaide Radar Survey (Australia) 168, 483
AMOR (New Zealand) 168, 398, 432, 435, 531, 559
Harvard Radar Survey (Havana, Ill.) 168, 482, 541
Jodrell Bank (UK) 167
Mogadishu (Somalia) 168
Ondrejov Observatory (Czech Republic) 168
Springhill Observatory (Canada) 168
Ukranian Kharkov Polytechnical Institute 168
University of Sheffield (UK) 167
SkyMet radar (global) 511
radiant 8
catalog 482
coordinates 41
daily drift 41
definition 39–40, 41
distribution in stream 499
size 499
true 40
radiation force 33
delay of orbital period 228, 229
efficiency 33
effect on dust trail 37, 228
factor $\beta$ 33
nonradial force 249
nonspherical grain 25
radiation force, nonradial
anisotropic emission and scattering 536
Poynting–Roberston drag 480, 536
Yarkovsky–Radzievskii effect 536
rates
variation during year 6
year-to-year variation 43
re-entry of sample return capsules 583
reservoirs of comets
Kuiper belt 62–65
Oort cloud 65–67
resonance 146, 148
corresponding semimajor axis 210
kozai 91
mean motion 89
secular 90, 148
retrograde orbit 88
$\rho$-Geminids 504
1993 outburst 504
Ribbon Model (see Orionids) 303
right ascension 41

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



Roche Lobe radius 156
rocking mirror 164
rotating argumen of perihelion 130
rubble pile 86

$s$ – differential mass distribution index 92
$\sigma$ – ablation coefficient 595
$\sigma_b$ – Stephan-Boltzmann constant 587
$S_2$, diatomic sulfur 75
satellites
  Chandra X-ray Observatory 555
  Deep Space 1 136
  Giotto 12, 15, 92, 95, 116
  HELIOS A and B 541
  HEOS 2 539
  Hubble Space Telescope 86, 284, 555
  International Cometary Explorer 112
  International Space Station 554
  IRAS 28
  IUE 75
  LDEF 552
  Mariner 4 555
  Mars Exploration Rover 570
  Mars Pathfinder 568
  Midcourse Space experiment 205
  Olympus 285, 554
  Pegasus 2 and 3 554
  Pioneer 10 544, 566
  Pioneer 11 544, 566
  Pioneer Venus Orbiter 567
  SEDS-2 554
  SOHO 423
  Solar Maximum Mission 423
  SOLWIND 423
  ULYSSES 544
  VeGa 15, 92, 95
  Viking Landers 568
  WIND 555
  Voyager 2 570
satellite impact hazard (see impact hazard meteoroids)
Saturn 155
  atmosphere 572
  B-ring spokes 573
  impact speed 573
  levitated dust over rings 573
  mass 155
  meteor showers 572, 758
  orbital period 155
  reflex motion 180
Saturn's moons
  meteor showers 758
  Titan's atmosphere 573
scattered disk object 64
Scorpiid–Sagittariid Complex 510–513
SDO 64
secondary nuclei 378
secular nutation cycle 131
secular perturbation 131
secular perturbation method 459
secular resonance 90
seep 21
semimajor axis 58
  delay from radiation pressure 229
September Sagittariids 136
serial association 481
Sextantids 398
  association with 2005 UD 399
shape cross section trail 321
shape of meteoroids 94
Shell Model (see Ribbon Model) 492
shooting star 3
shower versus sporadics 475
  percentage 482
    fireballs 484
    photography 484
    radar 482
  recognizing showers 478–482
    D-criterion 480
    direct association 481
    progressive search 481
    serial association 481
sintering and melting of grains 541
  inner edge of meteoroid survival 541
  smallest perihelion distance streams 541
size of comet nuclei
  from activity 79
size distribution index ($\alpha$) 92
  transformation to mass distribution 92
solar constant 587
solar longitude ($\lambda_\odot$) 158
solar system
  barycenter 179
  formation (in sequence:) 575
    infalling interstellar grains 575
    hierarchical accretion 576
    pebbles 576
    cometesimals 577
    protoplanets 578
    Moon 578
solar wind 31, 540
solar wind tracks 541
sound of meteors
  audible sounds 50
  sound speed 50
southern/northern branch 131
space weathering 437, 539
  chemical change of organic matter 541
  collisions with $\beta$-meteoroids 539

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



creation of glasses (amorphization) 541
density 437
exposure by energetic particles 540
fragmentation index 437
minimum size of grain surviving collisions 553
sintering and melting of grains 541
solar wind tracks 541
thermal heating 437
speed (see: velocity) 40
spin (see: comet nucleus, meteoroids)
spin-up
fragment relative speed 378
threshold spin period 378
spectrum of meteor 48
splitting nucleus 86
sporadic meteors 531
age 539
alignment of apside line with Jupiter 538
distribution of orbits 541
lifetime grains against collisions 539
lifetime of JFC meteoroids against ejection 534
mean impact speed 542
magnitude distribution index 95, 531
preferred aphelion at Jupiter 538
relation to zodiacal cloud 531
trapped in mean-motion resonances 534
typical size of meteoroid 95
typical mass of meteoroid 95
sporadic-E layer 45
sprite 236
sputtering 50
stars fell like rain 187
sublimation 24
Sun's reflex motion 179
long-period comet dust trail 192
phase lag 192
Sungrazer comets 423
Kreutz sungrazing group 423
subgroup I 424
subgroup II 425
retrograde orbit 423
Sungrazer Parent Comet 423
Sunskirting comets 423, 425
Kracht group 425
Marsden group 425
Meyer group 425
relation to Daytime Arietids 427–430
relation to $\delta$-Aquariids 430–432
relation to Machholz complex 425
Sunskirting streams 427–430, 499
Daytime Arietids 427–430
$\delta$-Aquariids 430–432
Geminids 402
surface temperature comet 76
swarm 539
synchrone/syndyne diagram 33
synchrone 35
syndyne 35

$t$ – time, duration 593
$T$ – temperature
$\tau$ – luminosity efficiency 593
$\tau$-Herculids 391
1930 outburst 392
1941 encounter 393
2022 return predictions 394
relation to May Bootids 394
Taurids 455
1990 possible outburst 468
1995 outburst 466
2001 possible outburst δ-Piscids 468
2001 possible outburst daytime 468
activity 7
age 456, 458
rotation of $\omega$ 456
young age 464
albedo of dust of Encke 135
association with 2004 $TG_{10}$ 470
association with 2P/Encke 133, 457
change of radiant with node 469
ejection speed from Encke 134
Encke at Earth's orbit 462
evolution of orbital elements 458
effect of comet ejection 461
fireball flares 465
fireball swarms 464
Giant Comet Hypothesis 455
N./S. difference in $\chi$ 466
nodal dispersion 469
origin in asteroid collision 459
progressive fragmentation index 465
size distribution of dust from Encke 134
trapping in mean-motion resonances 464
radiant 499
Taurid complex showers 456, 499
Arietids 456
$\chi$-Orionids 456
Daytime $\beta$-Taurids 456
Daytime S.-Arietids 456
Daytime $\zeta$-Perseids 456
Piscids 456
Taurid Complex of minor planets 462–464
among asteroids 464
associated meteoroid stream 502
candidate extinct comet nuclei 464
Taxonomic classes of asteroids 141–146
C-complex 143
S-complex 142

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



tektites 550
  formation 547
temperature
  dust grain day/night difference 537
  dust temperature versus distance from Sun 586
  formation temperature of ices 350, 577
  ice temperature versus distance from Sun 586
  meteor emission excitation temperature 51
  of surface comet 24, 76
  of zodiacal dust grains 532
$\theta$-Aurigids (see: Aurigids) 82
theoretical radiant 62
tidal force 14
time of maximum 158
Tisserand invariant 109
  asteroids ($T_J > 3$) 109, 520
  discriminate comets and asteroids 138
  extinct comet nuclei 137
  invariance, recognize streams 480
  relation to relative speed comet–Jupiter 109
  value for Halley-type comets (<2) 109
  value for Jupiter-family comets 109
Tisserand ($T$) criterion 597
toroidal source 515
trans-Neptunian object (TNO) 62
transmission grating 48
trailet 210, 266
  cut 321
  detachment 321
  shape of cross section 321
triangulation 39
true anomaly ($v$) 60, 61
true radiant 40
twin shower 440

underdense echoes 427
Uranus
  escape velocity 573
  impact speed 573
  meteor showers on Uranus 573, 758
  reflex motion 180
Uranus' Moon
  meteors on Triton 573
Ursids
  1945 outburst 266
  1973 outburst 266
  1986 outburst 267
  2000 outburst 267
    fragmentation properties 270
  association with 8P/Tuttle 263, 268
  Filament 263–265
  future dust trail predictions 641
  future Filament forecast 644
  historic dust trail encounters 641
  historic Filament observations 644
  in mean-motion resonances 265
  minimum distance 263
  outbursts at aphelion 263, 266
  radiant 263

$V$ – velocity (speed, vector)
$V_{ej}$ – ejection velocity (terminal, after leaving comet) 585
$V_g$ – gas ejection speed from comet 40, 586
$V_d$ – dust ejection speed 586
$V_\infty$ – atmospheric speed 41, 569
vector sum 40
velocity 40
  atmospheric 41
  geocentric 40
Venus 566
  altitude of meteors 566
  $\beta$-meteoroids impact rate 33
  coincidence of nodes 565
  Geminids at Venus 565
  meteors seen from Earth 566, 753
  meteor showers on Venus 752
  number of short-period comets 564
  peak brightness 566
vernal equinox 59, 159
Virginid Complex 503
  $\alpha$-Virginids 503
visual observations of meteors 202, 414

water in comets 22
  crystallization 22
  glass transition 22
  liquid water 22
  latent heat of sublimation 587
  mass of molecule 586
  ratio of specific heats 586
Whipple ejection speed 585
Whipple shields 555
width of dust trail
  broadening with time 249
  cross section 236
  function of miss-distance 237, 241
  intrinsic width at center 242

Yarkovsky–Radzievskii effect 536

$z$ – zenith angle, or angle from subsolar point 586
zenith attraction 41
zenith hourly rate 29, 41, 42–45, 274
zodiac 496
zodiacal cloud 531
  age 539
  distribution of orbits 541
  dust bands 29, 533

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-85349-1 - Meteor Showers and their Parent Comets
Peter Jenniskens
Index
More information



dust density past Jupiter 544
dust from Kuiper belt 544
dust spatial density at Earth 532
F-Corona
Gegenschein 544
grain size 532
grain temperature 532
inclination 532
irregularities in dust input 544
merging of meteoroid stream 533
meteoroids from HTC 532
meteoroids from JFC 532
orientation 532
total mass 532
zodiacal dust bands 29, 533
zone of influence 155
Laplace's formula 155
Roche lobe radius 156

© Cambridge University Press www.cambridge.org