Linked from "Appendix C" in *Why the Universe Is the Way It Is*

Part 1. Fine-Tuning for Life in the Universe

by Hugh Ross

For physical life to be possible in the universe, several characteristics must take on specific values, and these are listed below. In the case of several of these characteristics, and given the intricacy of their interrelationships, the indication of divine "fine-tuning" seems compelling.

1. Strong nuclear force constant
2. Weak nuclear force constant
3. Gravitational force constant
4. Electromagnetic force constant
5. Ratio of electromagnetic force constant to gravitational force constant
6. Ratio of proton to electron mass
7. Ratio of number of protons to number of electrons
8. Ratio of proton to electron charge
9. Expansion rate of the universe
10. Mass density of the universe
11. Baryon (proton and neutron) density of the universe
12. Space energy or dark energy density of the universe
13. Ratio of space energy density to mass density
14. Entropy level of the universe
15. Velocity of light
16. Age of the universe
17. Uniformity of radiation
18. Homogeneity of the universe
19. Average distance between galaxies
20. Average distance between galaxy clusters
21. Average distance between stars
22. Average size and distribution of galaxy clusters
23. density of giant galaxies during early cosmic history
24. Electromagnetic fine structure constant
25. Gravitational fine-structure constant
26. Decay rate of protons
27. Ground state energy level for helium-4

28. Carbon-12 to oxygen-16 nuclear energy level ratio
29. Decay rate for beryllium-8
30. Ratio of neutron mass to proton mass
31. Initial excess of nucleons over antinucleons
32. Polarity of the water molecule
33. Epoch for peak in the number of hypernova eruptions
34. Numbers and different kinds of hypernova eruptions
35. Epoch for peak in the number of type I supernova eruptions
36. Numbers and different kinds of type I supernova eruptions
37. Epoch for peak in the number of type II supernova eruptions
38. Numbers and different kinds of type II supernova eruptions
39. Epoch for white dwarf binaries
40. Density of white dwarf binaries
41. Ratio of exotic matter to ordinary matter
42. Number of effective dimensions in the early universe
43. Number of effective dimensions in the present universe
44. Mass values for the active neutrinos
45. Number of different species of active neutrinos
46. Number of active neutrinos in the universe
47. Mass value for the sterile neutrino
48. Number of sterile neutrinos in the universe
49. Decay rates of exotic mass particles
50. Magnitude of the temperature ripples in cosmic background radiation
51. Size of the relativistic dilation factor
52. Magnitude of the Heisenberg uncertainty
53. Quantity of gas deposited into the deep intergalactic medium by the first supernovae
54. Positive nature of cosmic pressures
55. Positive nature of cosmic energy densities
56. Density of quasars during early cosmic history
57. Decay rate of cold dark matter particles
58. Relative abundances of different exotic mass particles
59. Degree to which exotic matter self interacts
60. Epoch at which the first stars (metal-free pop III stars) begin to form
61. Epoch at which the first stars (metal-free pop III stars) cease to form
62. Number density of metal-free pop III stars
63. Average mass of metal-free pop III stars
64. Epoch for the formation of the first galaxies
65. Epoch for the formation of the first quasars

66. Amount, rate, and epoch of decay of embedded defects
67. Ratio of warm exotic matter density to cold exotic matter density
68. Ratio of hot exotic matter density to cold exotic matter density
69. Level of quantization of the cosmic spacetime fabric
70. Flatness of universe's geometry
71. Average rate of increase in galaxy sizes
72. Change in average rate of increase in galaxy sizes throughout cosmic history
73. Constancy of dark energy factors
74. Epoch for star formation peak
75. Location of exotic matter relative to ordinary matter
76. Strength of primordial cosmic magnetic field
77. Level of primordial magnetohydrodynamic turbulence
78. Level of charge-parity violation
79. Number of galaxies in the observable universe
80. Polarization level of the cosmic background radiation
81. Date for completion of second reionization event of the universe
82. Date of subsidence of gamma-ray burst production
83. Relative density of intermediate mass stars in the early history of the universe
84. Water's temperature of maximum density
85. Water's heat of fusion
86. Water's heat of vaporization
87. Number density of clumpuscules (dense clouds of cold molecular hydrogen gas) in the universe
88. Average mass of clumpuscules in the universe
89. Location of clumpuscules in the universe
90. Dioxygen's kinetic oxidation rate of organic molecules
91. Level of paramagnetic behavior in dioxygen
92. Density of ultra-dwarf galaxies (or supermassive globular clusters) in the middle-aged universe
93. Degree of space-time warping and twisting by general relativistic factors
94. Percentage of the initial mass function of the universe made up of intermediate mass stars
95. Strength of the cosmic primordial magnetic field
96. Capacity of liquid water to form large-cluster anions
97. Ratio of baryons in galaxies to baryons between galaxies
98. Ratio of baryons in galaxy clusters to baryons in between galaxy clusters
99. Rate at which the triple-alpha process (combining of three helium nuclei to make one carbon nucleus) runs inside the nuclear furnaces of stars
100. Quantity of molecular hydrogen formed by the supernova eruptions of population III stars
101. Epoch for the formation of the first population II (second generation) stars
102. Percentage of the universe's baryons that are processed by the first stars (population III stars)

103. Ratio of ultra-dwarf galaxies to larger galaxies
104. Constancy of the fine structure constants
105. Constancy of the velocity of light
106. Constancy of the magnetic permeability of free space
107. Constancy of the electron-to-proton mass ratio
108. Constancy of the gravitational constant
109. Smoothness of the quantum foam of cosmic space
110. Constancy of dark energy over cosmic history
111. Mean temperature of exotic matter
112. Minimum stable mass of exotic matter clumps
113. Degree of Lorentz symmetry or integrity of Lorentz invariantce or level of symmetry of spacetime
114. Nature of cosmic defects
115. Number density of cosmic defects
116. Average size of the largest cosmic structures in the universe
117. Quantity of three-hydrogen molecules formed by the hypernova eruptions of population III stars
118. Maximum size of an indigenous moon orbiting a planet
119. Rate of growth in the average size of galaxies during the first five billion years of cosmic history
120. Density of dwarf dark matter halos in the present-day universe
121. Metallicity enrichment of intergalactic space by dwarf galaxies
122. Average star formation rate throughout cosmic history for dwarf galaxies
123. Epoch of rapid decline in the cosmic star formation rate
124. Quantity of heavy elements infused into the intergalactic medium by dwarf galaxies during the first two billion years of cosmic history
125. Quantity of heavy elements infused into the intergalactic medium by galactic superwinds during the first three billion years of cosmic history
126. Average size of cosmic voids
127. Number of cosmic voids per unit of cosmic space
128. Percentage of the universe's baryons that reside in the warm-hot intergalactic medium
129. Halo occupation distribution (number of galaxies per unit of dark matter halo virial mass)
130. Timing of the peak supernova eruption rate for population III stars (the universe's first stars)
131. Ratio of the number density of dark matter subhalos to the number density dark matter halos in the present era universe
132. Quantity of diffuse, large-grained intergalactic dust
133. Radiometric decay rate for nickel-78
134. Ratio of baryonic matter to exotic matter in dwarf galaxies
135. Ratio of baryons in the intergalactic medium relative to baryons in the circumgalactic media
136. Level of short-range interactions between protons and exotic dark matter particles
137. Intergalactic photon density (or optical depth of the universe)
138. High spin to low spin transition pressure for Fe^{++}

139. Average quantity of gas infused into the universe's first star clusters

140. degree of suppression of dwarf galaxy formation by cosmic reionization

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