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Likelihood of Physical Contact with Intelligent Extraterrestrial Communities

$$N = R_* f_p n_e f_e f_i f_c^{(N)} L(N)$$

Pessimistic Approach:

$$= 1 \times 10^{-2} \times 3 \times 1 \times 10^{-1} \times 10^{-1} \times L$$

$$= 3 \times 10^{-4} L.$$

Then $L = < 10^3$ yrs $\Longrightarrow N < 0.3$

$L > 10^8$ yrs $\Longrightarrow N > 3 \times 10^4$.

Optimistic Approach:

$$N = 3 \times 10^{-1} \times 3 \times 1 \times 1 \times 0.1 \times L$$

$$= 10^{-1} L.$$

Then $L < 10^3$ yrs $\Longrightarrow N < 10^2$.

$L > 10^8$ yrs $\Longrightarrow N > 10^7$.

For purposes of the following discussion, we adopt $N = 10^6$.

From Sänger (JBIS, 18:273, 1962):

Mass ratio for relativistic rocket with exhaust velocity w:

$$\frac{m_f}{m_i} = \left(\frac{1-\beta}{1+\beta}\right)^{c/2w}$$

where $\beta = v/c$ is the Einstein number (cf. Mach no.).
For a photon rocket, $w = c$. Then

$$\frac{m_f}{m_i} = \left(\frac{1-\beta}{1+\beta}\right)^{1/2}.$$

Let $v = c(1-\varepsilon)$. $\therefore \beta = \frac{v}{c} = 1-\varepsilon$.

$$\therefore \frac{m_f}{m_i} = \left(\frac{1-1+\varepsilon}{1+1-\varepsilon}\right)^{\frac{1}{2}} = \left(\frac{\varepsilon}{2-\varepsilon}\right)^{\frac{1}{2}} \simeq \sqrt{\frac{\varepsilon}{2}}$$

$\therefore \varepsilon = 0.1 \Longrightarrow \frac{m_f}{m_i} \simeq \sqrt{5\times10^{-2}} \simeq 0.2$; $\frac{m_i}{m_f} = 5$

$\varepsilon = 0.01 \Longrightarrow \frac{m_f}{m_i} \simeq \sqrt{5\times10^{-3}} \simeq 0.07$, $\frac{m_i}{m_f} = 14$

$\varepsilon = 0.001 \Longrightarrow \frac{m_f}{m_i} \simeq \sqrt{5\times10^{-4}} \simeq 0.02$; $\frac{m_i}{m_f} = 50$

These are very reasonable mass ratios.

The onboard time under const. acceleration a is

$$t = \frac{2c}{a} \operatorname{arccosh}\left(1 + \frac{aS}{2c^2}\right).$$

where S is the journey distance measured in the rest frame.

Times are doubled to allow for deceleration.

		t
arccosh	100 000	= 12.2 yrs.
arccosh	10^6	= 14.5
arccosh	10^7	= 16.8
arccosh	10^8	= 19.1

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Consider $a = 980\ cm\ sec^{-2}$ & $S = 1\ l.y. = 9.5\times10^{12}\ km = 9.5\times10^{17}\ cm.$

$$\therefore \frac{aS}{c^2} = \frac{9.5\times10^2\times9.5\times10^{17}}{9\times10^{20}} \simeq 1.$$

$$\therefore t = \frac{3\times10^{10}}{9.8\times10^2}\ \text{arccosh}\ 2 =$$

Now $\cosh 1.32 = 2.$

$$\therefore t = \frac{3\times1.32}{9.8}\times10^8 = 4.0\times10^7\ sec \simeq 1\ yr.$$

$\therefore$ if $a = 1\ g$, it takes 1 yr to reach 1 l.y.

10 l.y. : $\text{arccosh}\ 11 = 3.1$

$$\therefore t = 3.1\times3.1\times10^7 \simeq 3\ yrs.$$

100 l.y. : $\text{arccosh}\ 101 = 5.3$

$$\therefore t = 3.1\times5.3\times10^7 \simeq 5\ yrs$$

1000 l.y. : $\text{arccosh}\ 1001 = 7.6$

$t = 8$ yrs.

10000 l.y. : $\text{arccosh}\ 10001 = 10.0$

$t = 10$ yrs.

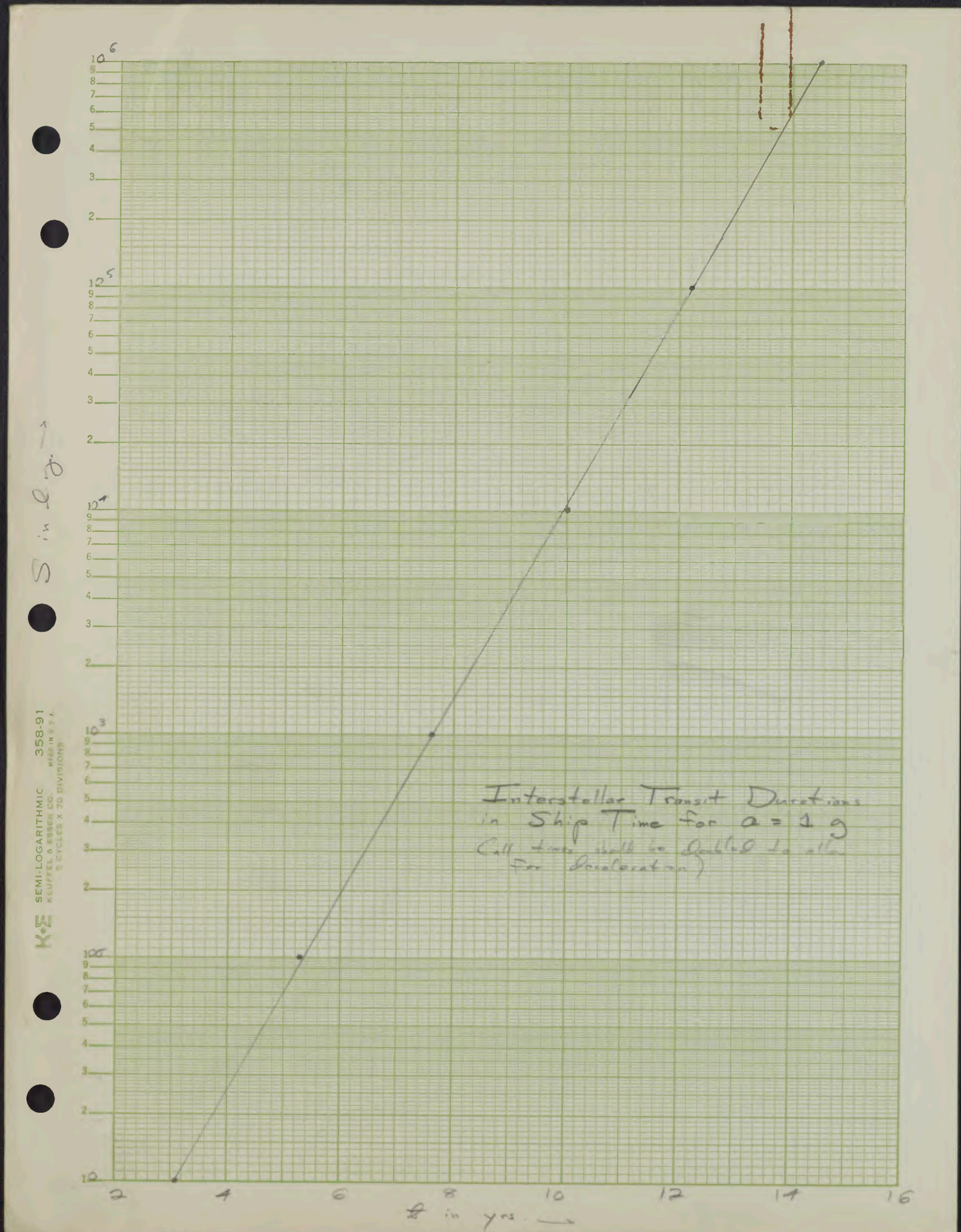
For $x > 10$, $\cosh y \simeq \frac{1}{2}e^y.$

$$\therefore y = \text{arccosh}\left[\tfrac{1}{2}e^y\right]$$

Let $\frac{1}{2}e^y = x.$ $\therefore \ln x = \ln\frac{1}{2} + y.$

$$\therefore y = \ln x - \ln\tfrac{1}{2} = \ln 2x$$

$$\therefore \text{arccosh}\ x = \ln 2x$$


Interstellar Transit Durations
in Ship Time for a = 1 g
(All times should be doubled to allow for deceleration)
S in l.y.
t in yrs
2
4
6
8
10
12
14
16
10
100
10^3
10^4
10^5
10^6
SEMI-LOGARITHMIC 358-91
KEUFFEL & ESSER CO.
5 CYCLES X 70 DIVISIONS

For intergalactic distances, + these acceleration, the eq. reduces to

$$t \approx 2\frac{c}{a} \ln [2aS/c^2]$$

The result is that even intergalactic travel becomes reasonable.

However, we choose a time limit on the round trip; say, 10^5 yrs. on the home planet. This restricts travel to within the galaxy.

Assume the gods have lifetimes $\sim 10^2$ yrs. Assume suspended animation in transit. If expedition is to be effective with follow-up (cf Oannes case) several generations of gods required or suspended animation between visits. [Diff. names for Oannes' successors → former]. No possibility of sending for another expedition within $\sim 10^2$ yrs, unless base is < 30 l.y. away.

Let each of the N planets in communicative phase have q vehicles on continuous patrol. Each vehicle can effect at least one contact per journey. Each vehicle is gone, say, 10^2 yrs. ∴ taking the lifetime of the communicative phase to be L, the number of contacts effected by each civilization is

$$\sim q \frac{L}{10^2}$$

Total no. contacts by all *'s in L yrs is

$$q N L/10^2$$

∴ No contacts per yr. is

$qN/10^2$.

With $L = 10^8$ yrs, + $q = 10^2$, + $N = 10^6$, $\exists$

10^6 contacts / yr for all *'s.

10^8 total contacts by each * in L

10^{14} contacts by all *'s in L.

∴ if contacts are made on a purely random basis, each * should be contacted once each 10^5 yrs if $\exists$ 10^{11} *'s.

We have taken $f_p = 10^{-1}$. The intelligent communities should know which *'s probably have planets ∴ on avg. each planetary system contacted randomly once each 10^4 yrs. Where the galactic survey indicates life, + in particular, glimmerings of intelligence, contact will be more frequent. Man emerged several $\times 10^6$ yrs ago. This event must have been duly noted. ∴ it is quite likely, in the above framework, that the avg. interval between contacts on * during the last 10^4 or 10^5 yrs is $< 10^3$ yrs. ∴ where are they?

$\boxed{\text{Oannes.}}$

Why no subsequent contact? "I'm sorry little boy, we're ramout of candy." Hollywood o.t. portrayals

If contact once made, very unlikely that observation is not maintained.

The above treatment tends to depend only insensitively on N: because the more unlikely life is, the fewer planetary systems will be investigated provided the survey ships know the parameters involved. There is no distance problem w. relativistic spaceflight.

Oannes is impressive in its directness + in the critical time of the presumed contact. Difficulties w. legends: example in Cosmos + History. Good analogue example in Mead. (European sailing ship contact w. N.W. coast American Indians.) Dragons only en passant. E.t. physiology bound to be diff. But once, e.g., Zinjanthropus observed could be a selection for galactic community most like humans to effect contact later. Because of contraction for $\beta \to 1$, it is even possible that Oannes is alive today. Time travel into future.

Acknowledge Backus

Once contact effected, info must go into a central galactic info. repository.

Approach of paper: much recent discussion on methods of contact. Microwave, light, unmanned vehicles. Purpose of this paper is to examine the likelihood of direct contact between galactic civilizations by interstellar space flight.

Dragon, year 1

Communication w. unmanned relativistic rocket almost impossible. Much better to man it. Need direct contact for pre-communicative phase to help out. Because of mass limitations, no massive technical assistance: just info.

Zigarrent; chamber for the gods.

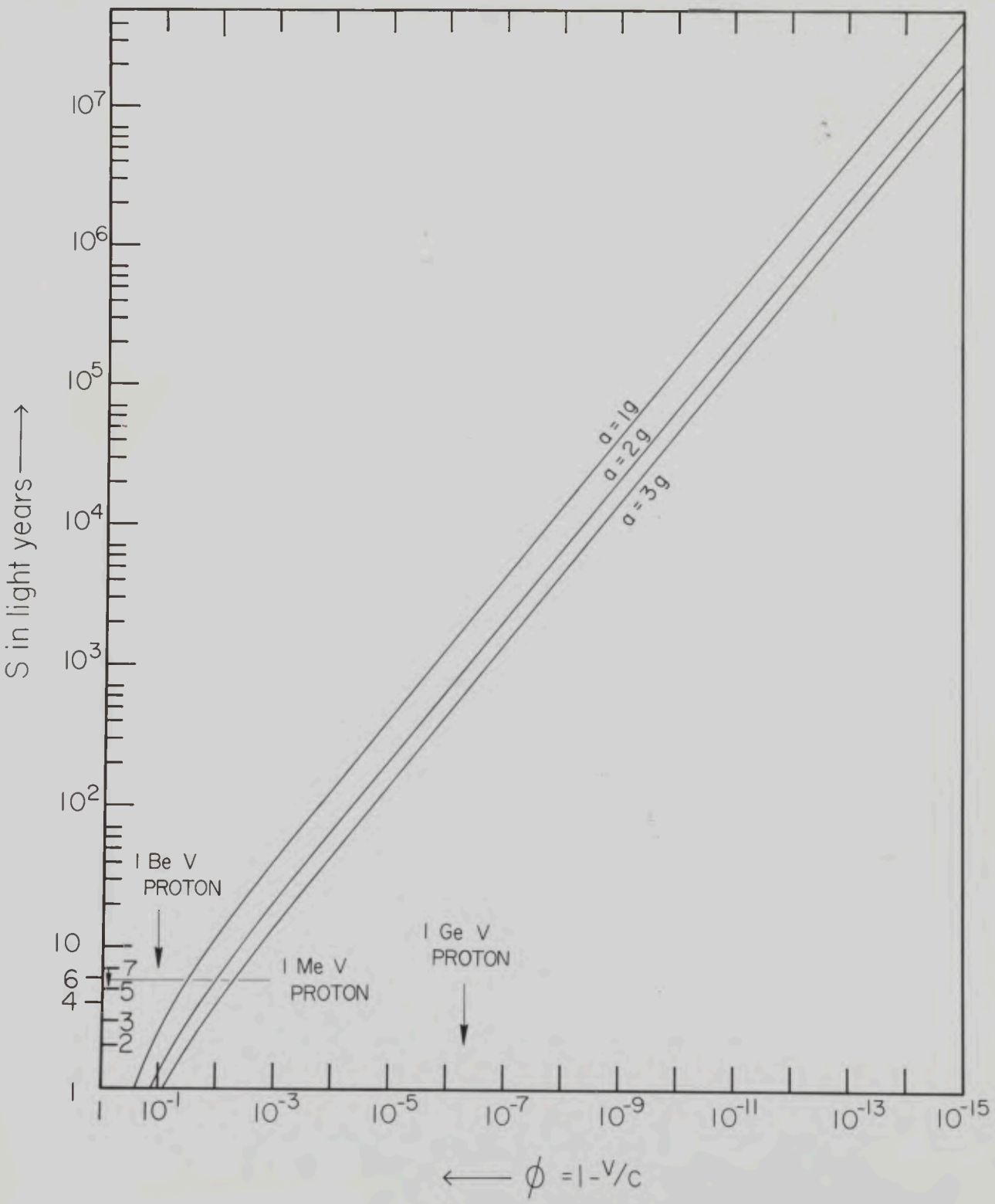
(1) quantum jump of Sumerian investigation (Jacobsen)
(2) cities belong to the gods. Ziggurats.
Eg. scale expedition in several cities
over several centuries.

Shepherd (J.B.I.S. 11: 149, 1952)

$$S = \frac{1}{a'}\left[\frac{1}{\gamma} - 1\right] \; ; \; \gamma = \sqrt{1 - \frac{v^2}{c^2}} = \sqrt{1 - \beta^2}$$

Outline:

1. Intro.: Means of communicating. Here study direct physical contact.
2. Number of intelligent communities, N. NAS framework. Acknowledge Drake
3. Interstellar space flight. Techniques, difficulties, and arcade argument. Galaxy intercommunicating. Cf Purcell
4. Consequences. Community organization, central data repository. Frequency of contact. Where are they? Physiological types on other *'s
5. Possible case of terrestrial contact; the Annedotion Musari.
   (a) Alexander Polyhistor
   (b) Abydenus
   (c) Apollodorus
   (d) Alexander Polyhistor on the Great Flood
6. Connection with early Sumerian history and the subsequent development of civilization.
7. Difficulties in interpreting myths (Eliade, Mead, gods must be in heaven) + other research poss. (dragons)
8. Future contacts; mode of entry into galactic community


S in light years ⟶
10^7
10^6
10^5
10^4
10^3
10^2
10
6
4
1
7
5
3
2
a = 1g
a = 2g
a = 3g
1 Be V
PROTON
1 Me V
PROTON
1 Ge V
PROTON
1
10^{-1}
10^{-3}
10^{-5}
10^{-7}
10^{-9}
10^{-11}
10^{-13}
10^{-15}
⟵ $\phi = 1 - v/c$

Cab 1019

3d. of Health CA 7-1300 Town Taxi #38
Boston Health Dept. Haymarket Sq.

10 BeV : $\sim 2\ cm^{-2}\ sec^{-1}$; $\tau \sim 3\times10^{7}$ yrs $= 10^{15}$ secs.
Trapping lifetime (Simpson)

N planets $\times$ q ships planet^{-1} yr^{-1} $\times$ t yrs avg. voyage

Nqt ships/galaxy

Each ship has velocity $v \simeq c$ + collecting area a_s cm^2,

$n_i \sim 1\ cm^{-3}$, $n_i v = J\ cm^{-2}\ sec^{-1}$ through collecting area

$\therefore J \sim 3\times10^{10}\ cm^{-2}\ sec^{-1}$.

Attenuated by ratio of areas, a_s/a_g, where a_g is cross-sectional area of galaxy.

$a_s = \pi(2000\ km)^2$ $\qquad$ 1 l.y. $= 10^{13}$ km.

$a_g = \pi(3\times10^{17}\ km)^2$ $\qquad$ 30000 l.y. $= 3\times10^{17}$ km

$\therefore a_s/a_g \simeq (10^3/10^{17})^2 = 10^{-28}$.

$\therefore 3\times10^{10}\times10^{-28}\times Nqt \simeq 2$ $\qquad$ $n_i v a_s$ = no. parts sec^{-1} ship^{-1}

$\therefore Nqt \sim 10^{18}$ $\qquad$ $J_\oplus a_g$ = no. parts sec^{-1} galaxy^{-1}

For $N = 10^6$, $t = 10^3$, $q \sim 10^9$, impos

$$n_i v \times \frac{a_s}{a_g} \times Nqt = J_\oplus$$

Should really be $n_i v a_s (Nqt)$ no. parts produced by all ships sec^{-1}

$=$ no. parts lost from galaxy sec^{-1}.

$\exists$ N^{cr} ~~parts~~ in volume of galaxy. Lifetime = τ.

$$\therefore \boxed{n_i v \sigma_s N_g t = N/\tau}$$

N: 1 c.r. ~~part~~. cm^{-3} × ~~[illegible]~~ $\pi \times (3\times10^{23})^2 \times 3\times10^{20}$ cm^3

$\simeq 10^{27+46+20} = 10^{68}$ ~~cm~~

$$\begin{array}{r} 68 \\ +1 \\ \hline 27 \end{array} \qquad \begin{array}{r} 15 \\ 10 \\ 16 \\ \hline 41 \end{array}$$

$$\therefore N_g t = \frac{10^{68}}{10^{15}} \times \frac{1}{3\times10^{10} \times \pi \times 4 \times 10^{16}} \sim \frac{1}{30} \times 10^{27} = 3\times10^{25}$$

~~wow~~ yet.

Another difficulty is ~~that~~ 10 BeV ~~proton~~ avg. c.r. energy → voyages only to nearest *'s. ∴ this is a minor contribution to the ~~total~~ galactic c.r. flux.