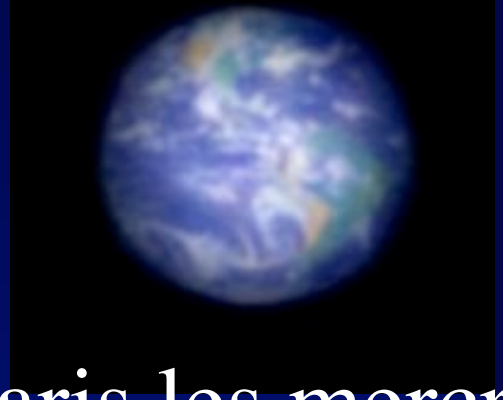
Collège de France
Chaire d ’Astrophysique Observationnelle

Exo-planètes, étoiles et galaxies : progrès de l'observation



- Six cours à Paris les mercredis du 6 Avril au 1er Juin
- Détails sur www.college-de-france.fr/chaires/chaire11/lise.html
- les fichiers .pdf des projections seront affichés

Programme

voir : www.college-de-france.fr/

- Dernier cours aujourd'hui
- Le cours n'aura pas lieu l'an prochain

Aujourd'hui :

Voir en détail des exo-Terres avec civilisation ?

le problème technique

Séminaire à 18h: Thierry Fusco, ONERA «

Optique adaptative NAOS au VLT»

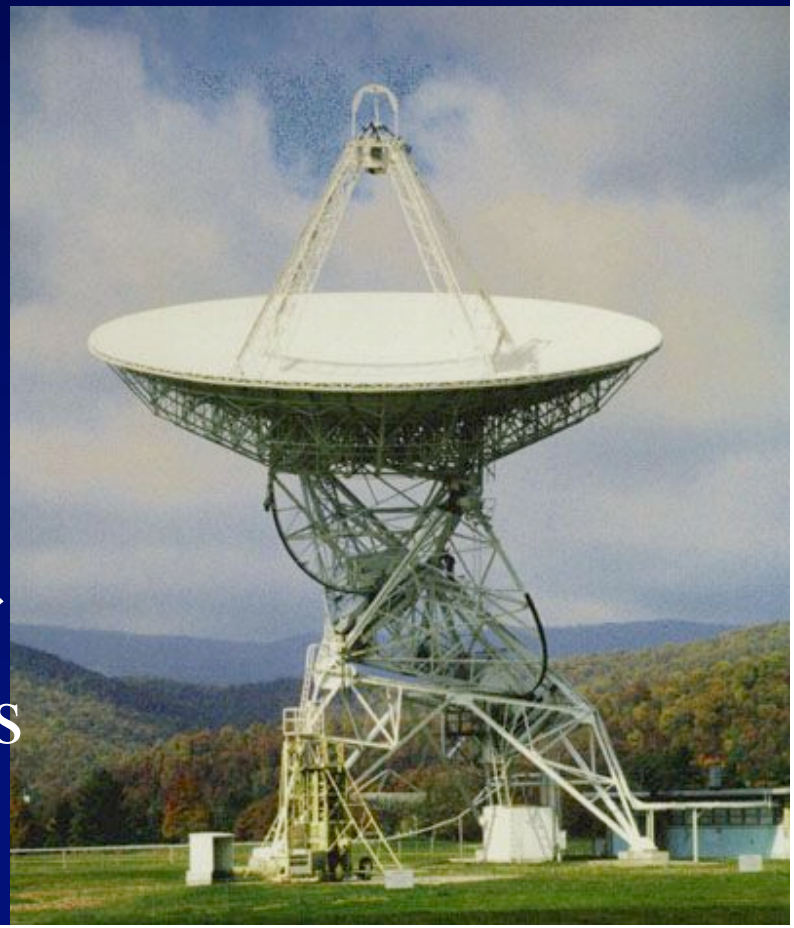
« Autres mondes »: une vieille idée

- Aristote
- Epicure
- Cyrano de Bergerac
- Giordano Bruno

1- Les projets SETI* et « Optical SETI »

*Search for Extra-Terrestrial Intelligence »

- Aussi « Search for Extra-Terrestrial Technology »
- Tentative de détection de signaux radio « intelligents »
- Ou d'émissions laser dirigées



- Recherche d'intelligence extra-terrestre (SETI)

- 1959: SETI radio
  - Recherche d’un signal
    - Soit émis intentionnellement à notre attention
    - Soit une 'fuite' d’émission radio, inhérente à l'activité interne d'une société ETI, dont le contenu ne nous serait pas destiné mais dont la forme serait clairement d'origine artificielle.

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- Giuseppe Cocconi & Philip Morrison, physiciens à Cornell University en 1959
- Article fondateur dans *Nature*, September 19, 1959
- Mais leur demande d'observations est refusée par l'observatoire Jodrell Bank

SEARCHING FOR INTERSTELLAR COMMUNICATIONS

By GIUSEPPE COCCONI* and PHILIP MORRISON†
Cornell University, Ithaca, New York

NO theories yet exist which enable a reliable estimate of the probabilities of (1) planet formation; (2) origin of life; (3) evolution of societies possessing advanced scientific capabilities. In the absence of such theories, our environment suggests that stars of the main sequence with a lifetime of many billions of years can possess planets, that of a small set of such planets two (Earth and very probably Mars) support life, that life on one such planet includes a society recently capable of considerable scientific investigation. The lifetime of such societies is not known; but it seems unwarranted to deny that among such societies some might maintain themselves for times very long compared to the time of human history, perhaps for times comparable with geological time. It follows, then, that near some star rather like the Sun there are civilizations with scientific interests and with technical possibilities much greater than those now available to us.

* Now on leave at CERN, Geneva.
† Now on leave at the Imperial College of Science and Technology, London, S.W.7.

To the beings of such a society, our Sun must appear as a likely site for the evolution of a new society. It is highly probable that for a long time they will have been expecting the development of science near the Sun. We shall assume that long ago they established a channel of communication that would one day become known to us, and that they look forward patiently to the answering signals from the Sun which would make known to them that a new society has entered the community of intelligence. What sort of a channel would it be?

The Optimum Channel

Interstellar communication across the galactic plasma without dispersion in direction and flight-time is practical, so far as we know, only with electromagnetic waves.

Since the object of those who operate the source is to find a newly evolved society, we may presume that the channel used will be one that places a minimum burden of frequency and angular discrimi-

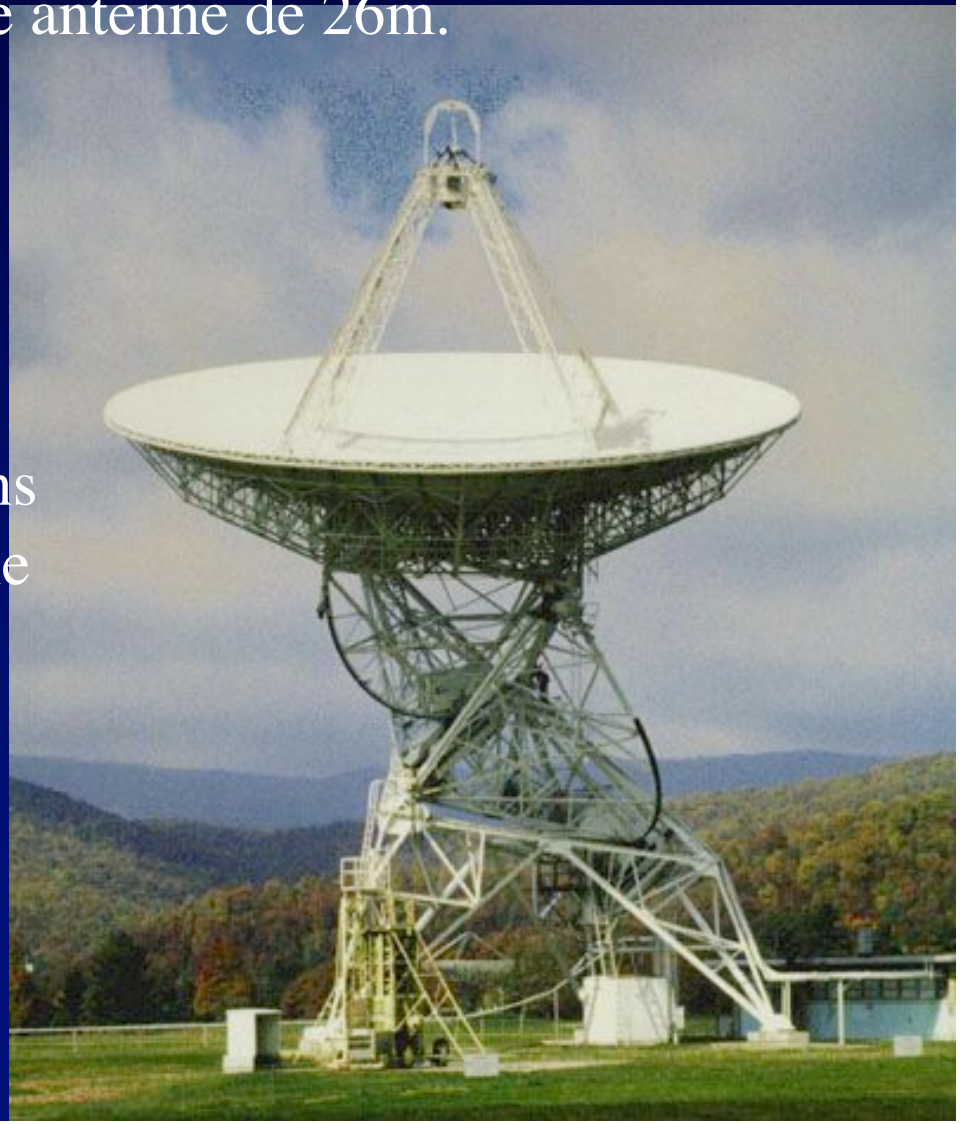
Emprunté à Luc Arnold, 2005:

Mars 1959: Frank Drake, indépendamment de Cocconi et Morrison, calcule que si un signal radio est émis depuis la Terre avec la techno humaine existante, il est détectable à 10 AL par cette même techno, une antenne de 26m.

Avec le soutien de Otto Struve,

Drake obtient des observations à Green Bank avec la nouvelle antenne de 26m

-> Projet OZMA
2 étoiles G
tau Ceti, epsilon Eridani



- Les SETI actuels peuvent détecter 3kW à 100 AL si le faisceau est focalisé vers la Terre
- Puissance de l'émetteur de RMC à Roumoules: 2 MW

  -> détectable à environ 2500 AL (? Diamètre de l'émetteur ?)

Emprunté à Luc Arnold, (Arnold et al. Ap.J. 2005):

- Les écoutes radio continuent, entre 1 et 3 GHz (transparence du ciel, *water hole*, 1.4 GHz hydrogène neutre, lambda 21cm)
  - 1971: NASA Cyclops report
  - OZMA II: 674 étoiles écoutées 500 h entre 1972 et 76, antenne 43m
  - Années 70's: META (NASA, Harvard), SERENDIP (NASA, Univ. California), Ohio State Univ. ('Wow!' signal en 1977)
  - 1984 création SETI Institute
  - 1985-95 META I (Million channels), META II en Argentine: 8,4 millions de canaux, 0.05Hz de résolution, 93% de sky coverage. 50 'alertes'.
  - 1992 NASA/JPL High Resolution Microwave Survey (HRMS), entre 1 et 3 GHz, 20 millions de canaux de 1 Hz.
  - NASA abandonne SETI en 1993, mais HRMS renaît de ses cendres… Project Phoenix (SETI Institute)
  - 1996 SERENDIP III, U.C. Berkeley, sur Arecibo, et SETI@home
  - Aujourd'hui BETA, SERENDIP IV (168 millions de canaux) et seti@home, Southern SERENDIP en Australie, etc.
  - Projets futurs…actualité:
    - SETI Institute http://www.seti-inst.edu/
    - The Planetary Society http://www.planetary.org/

SETI optique

- Contexte historique: 1er laser en 1960 par Maiman
- 1961: R.N. Schwartz et C. Townes (Nobel en 1964, inventeur du maser en 1954) proposent de rechercher des émissions laser continues

(Reprinted from *Nature*, Vol. 190, No. 4772, pp. 205–208, April 15, 1961)

INTERSTELLAR AND INTER-PLANETARY COMMUNICATION BY OPTICAL MASERS

By Dr. R. N. SCHWARTZ and
Prof. C. H. TOWNES*
Institute for Defense Analyses, Washington, D.C.

LONG-RANGE communication by radio-waves is already well known, and the possibility of interstellar communication by radio waves in the microwave region has been suggested in several interesting proposals[1-3] to search for signals from intelligent beings on planets associated with nearby stars. The supposition is that curiosity such as our own would motivate advanced civilizations associated with stars other than our Sun to make determined efforts to communicate with whatever other intelligent life might exist on neighbouring planetary systems. Radio-waves have, because of our present state of technological development, dominated the field of very long-distance communication, and perhaps for this reason these proposals gave particular attention only to the radio region. It appears, however, that we are now not very far from the development of maser oscillators and other appropriate apparatus in or near the optical region which will also allow detectable light signals to be beamed between planets of two stars separated by a number of light years.

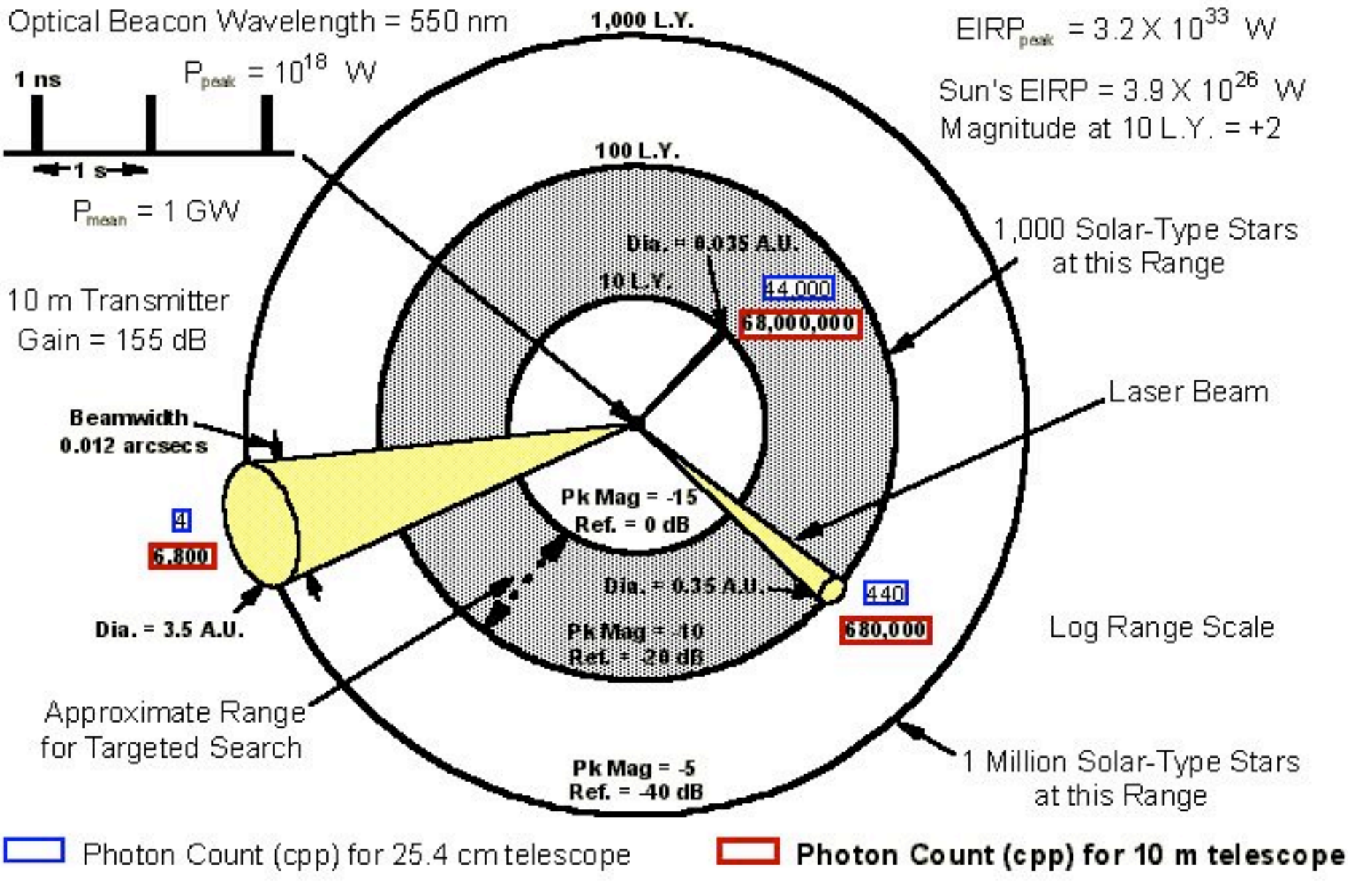
Our own maser techniques in the optical and nearby spectral regions are still in a rudimentary stage; no such operating device was known a year ago[4,5]. Another ten years should bring very marked development. Further, only historical accident seems to have prevented discovery of optical masers thirty or more years ago, in which case they would probably already have been in an advanced stage of development. This implies that a separate civilization might have inverted our own history and become very sophisticated in the use of optical or infra-red masers rather than in the techniques of short radio-waves.

We propose to examine the possibility of broadcasting an optical beam from a planet associated with a star some few or some tens of light-years away at sufficient power-levels to establish communications with the Earth. There is some chance that such broadcasts from another society approximately as advanced as we are could be adequately detected by present telescopes and spectrographs,

* On leave from Columbia University, New York.

Emprunté à Luc Arnold, (Arnold et al. Ap.J. 2005):

Kingsley
2001, SPIE



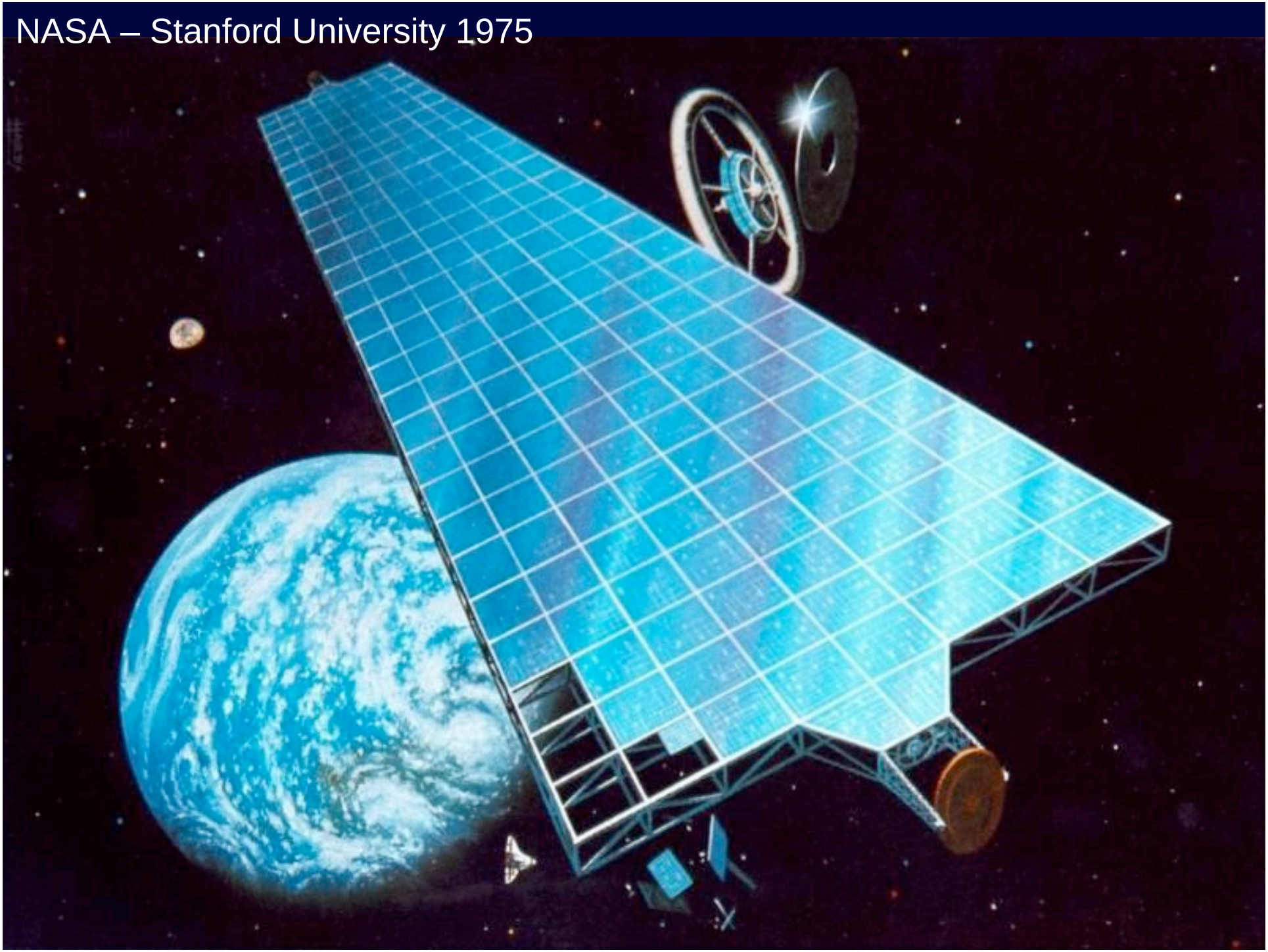
2 - Les projets terriens de « villes orbitales »

Emprunté à Luc Arnold, (Arnold et al. Ap.J. 2005):

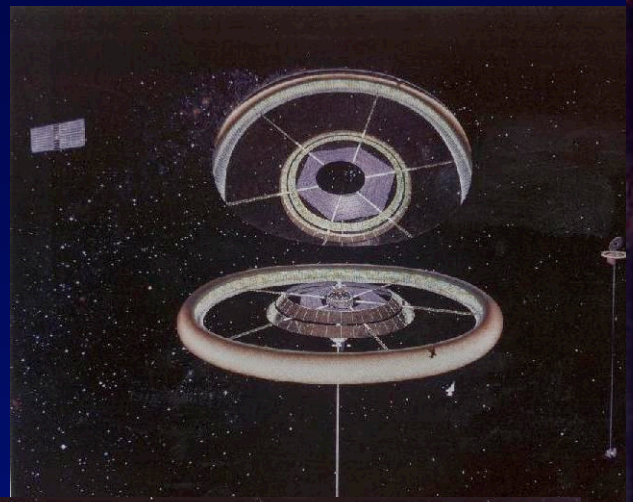
Première proposition par Werner von Braun en 1952

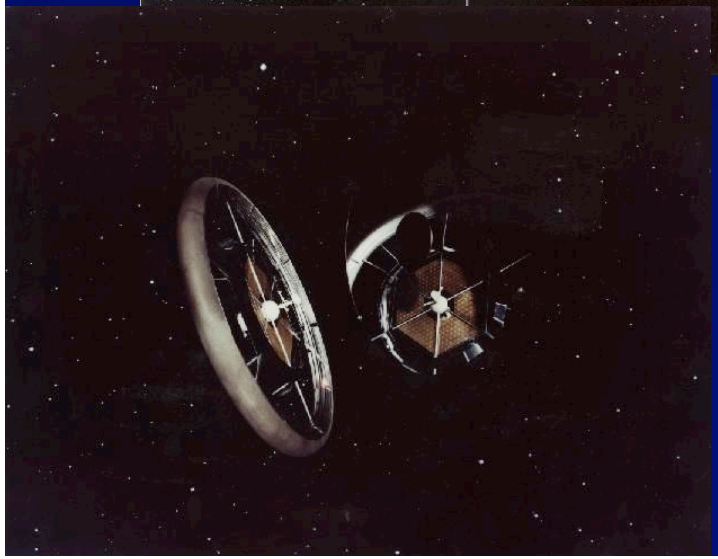
diamètre 75 m,
un tour en 22s,
gravité: 0.3 g

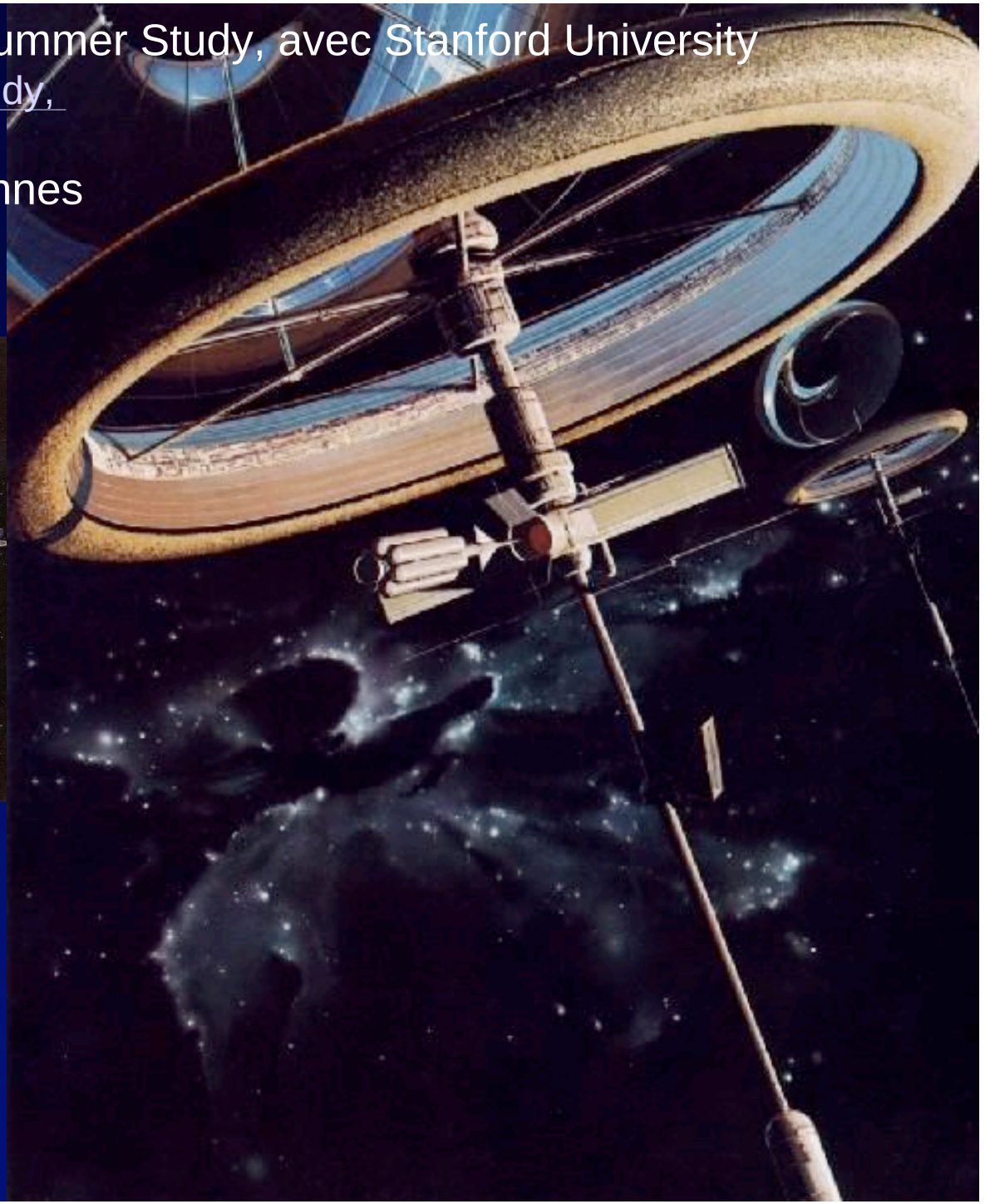
NASA – Stanford University 1975



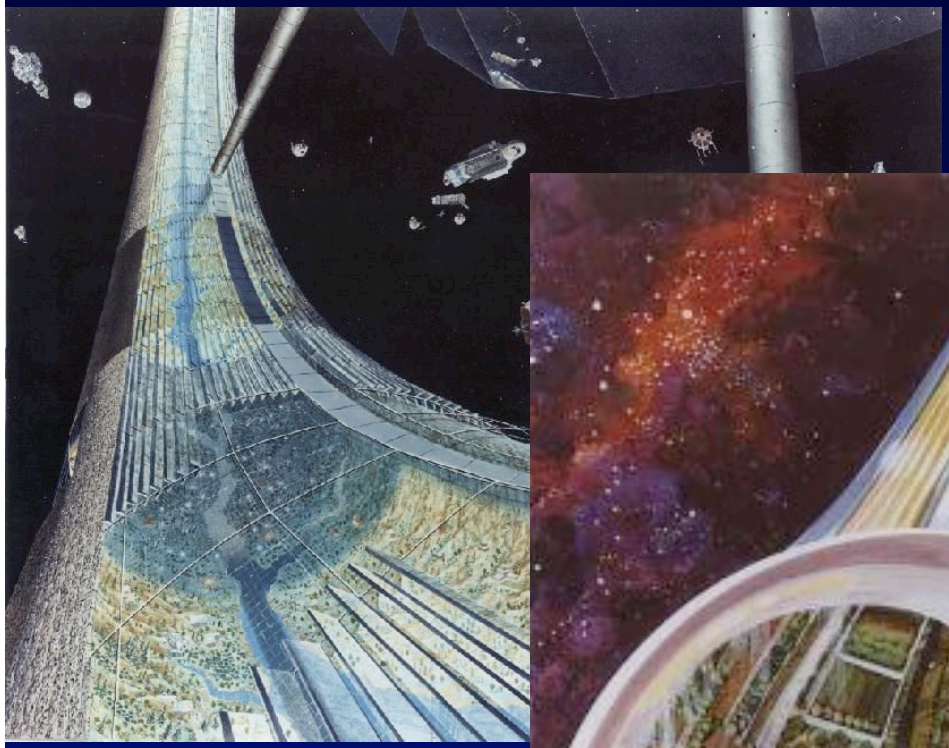
Stanford Torus: 1975 NASA Summer Study, avec Stanford University
(Space Settlements: A Design Study,
NASA Publication SP-413)
diamètre 1,6 km, 10000 personnes

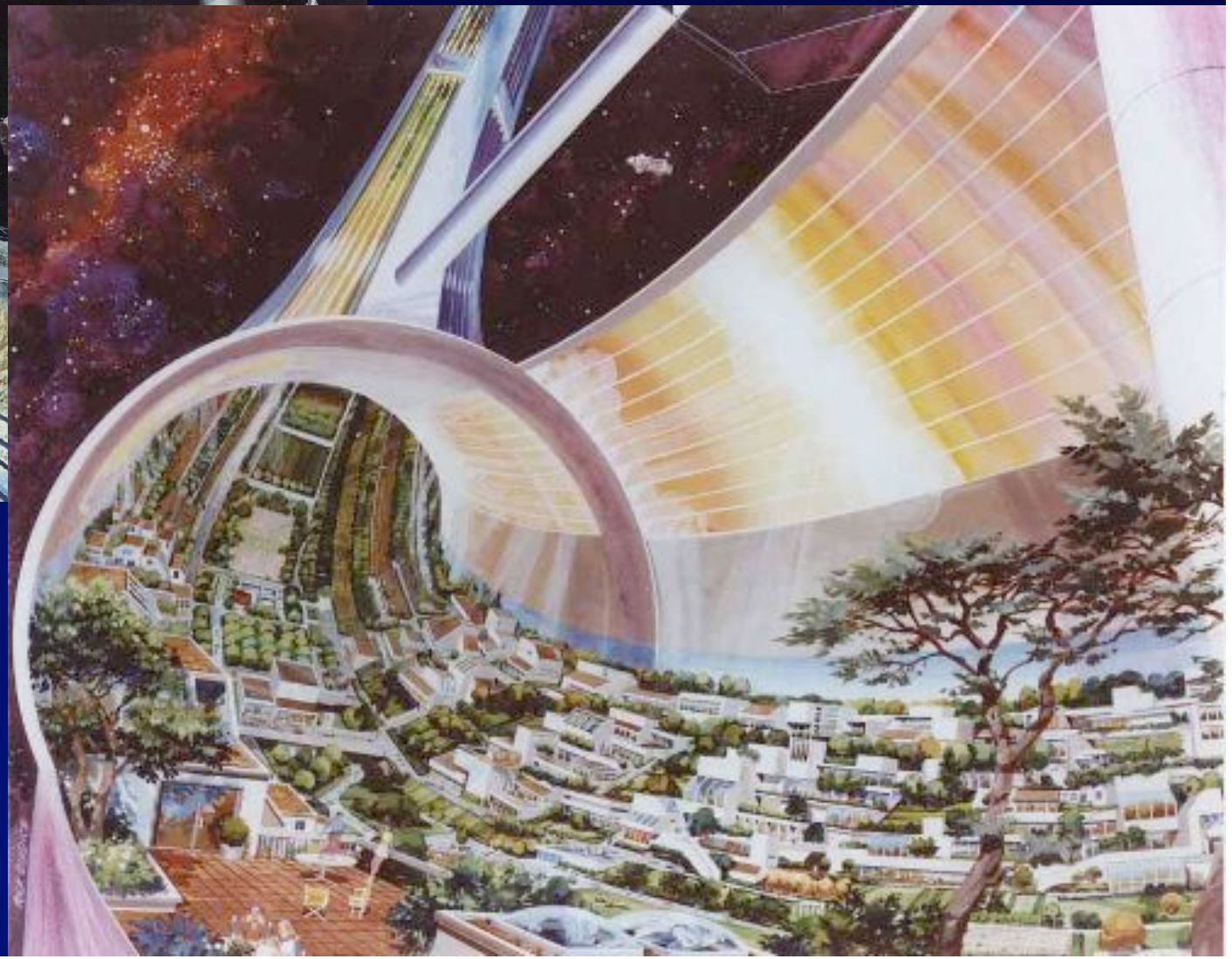




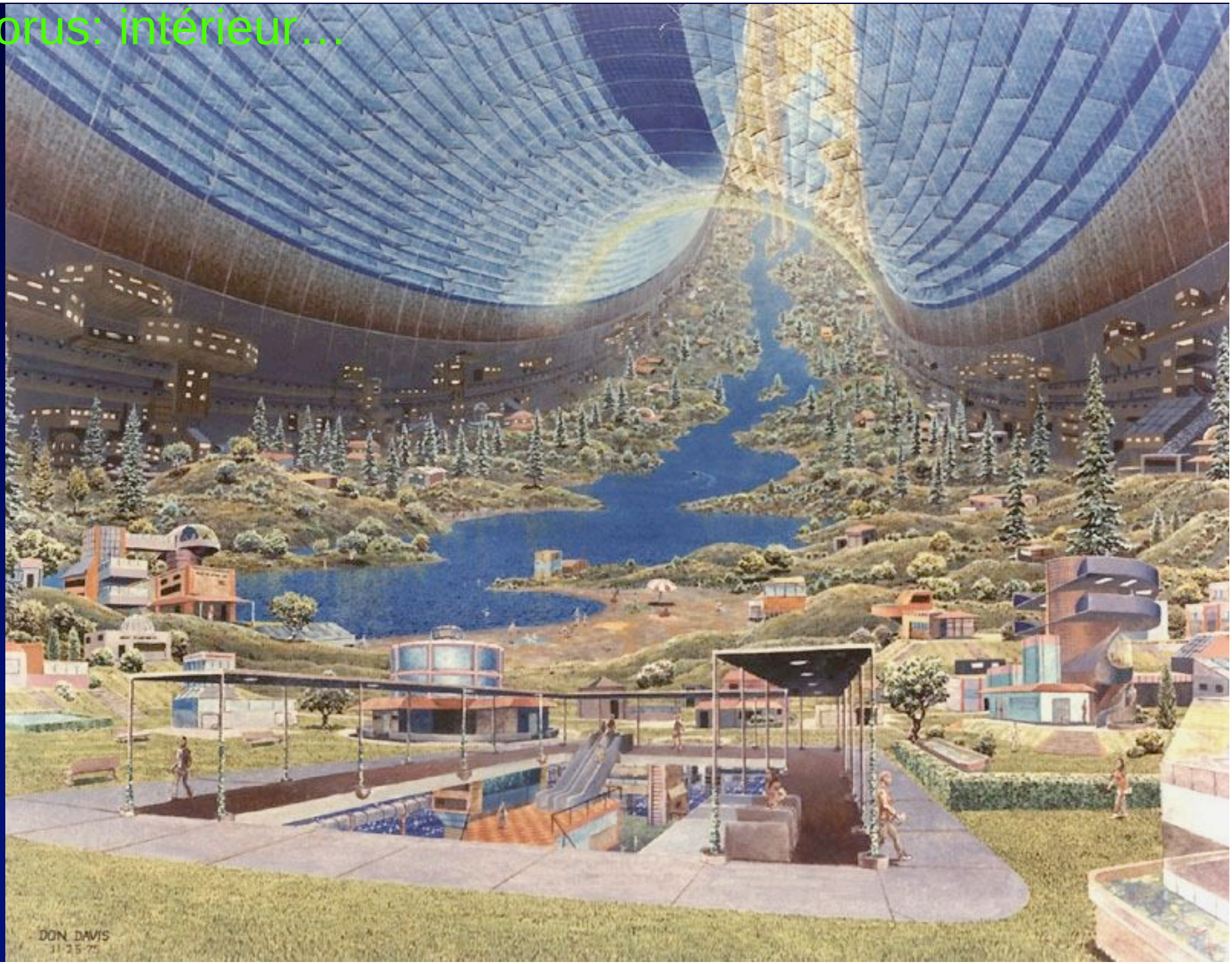


Torus: construction et intérieur….



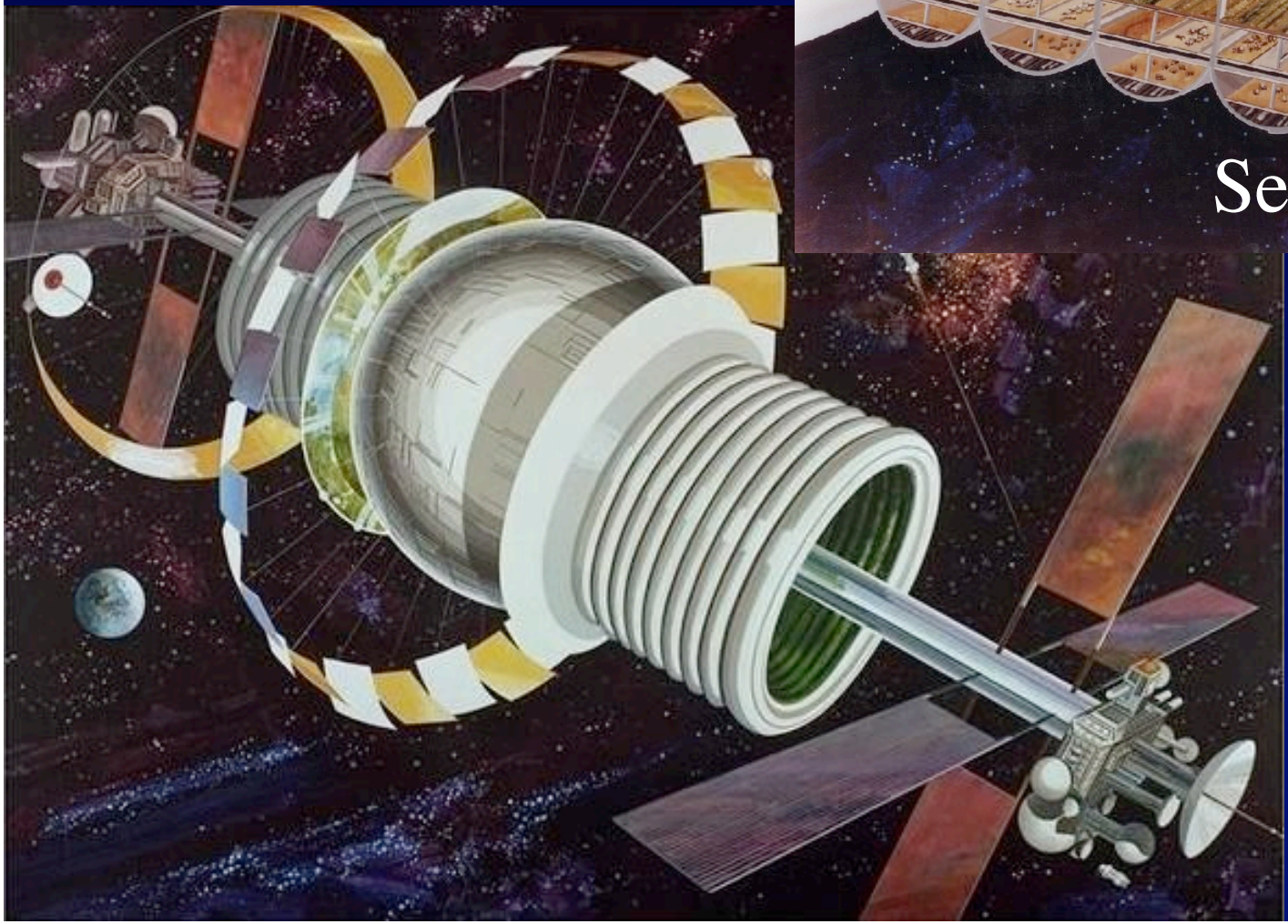


Torus: intérieur…

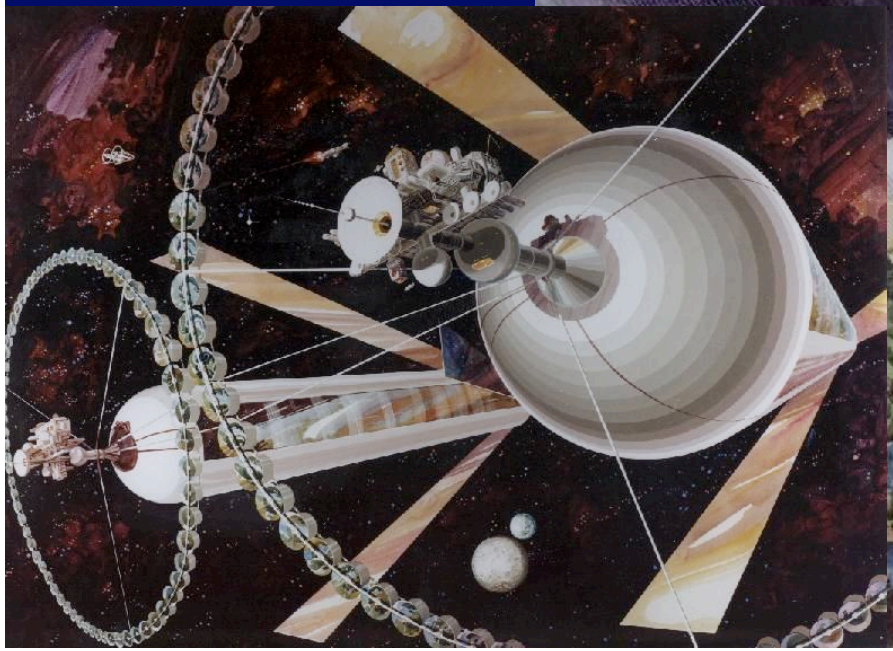


Bernal sphere (70’s)
Etudes NASA (1976 NASA Study on Space Manufacturing)
diamètre 1,6 km, 10 000 habitants

Serres de culture

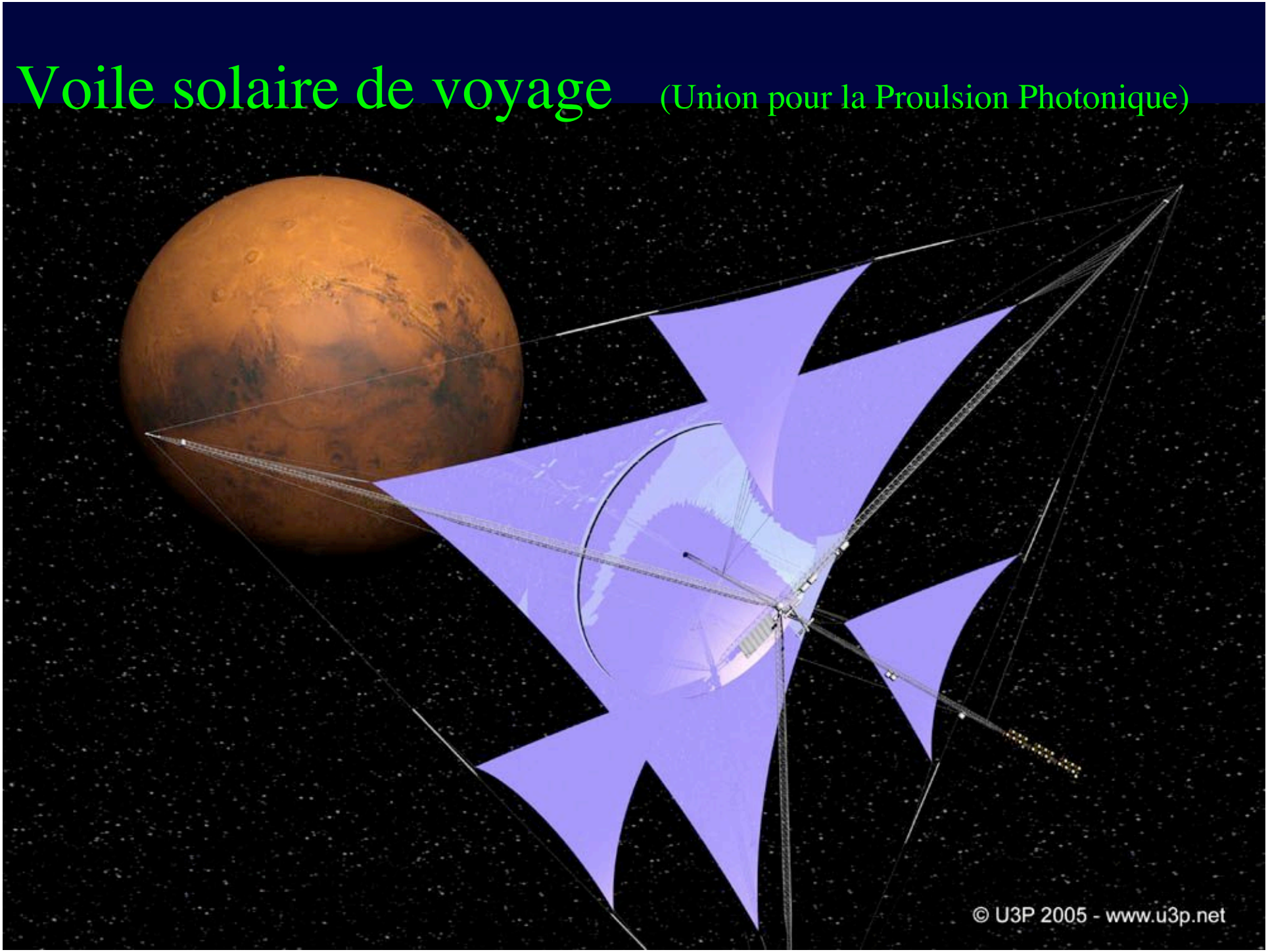


Habitats de O’Neill: cylindres 32 à 200km de long (1976 NASA Study on Space Manufacuring)



- Tous ces objets sont trop petits pour être vus par transit …
- Image directe ? Quel hypertélescope ?

Voile solaire de voyage (Union pour la Proulsion Photonique)



Emprunté à Luc Arnold, (Arnold et al. Ap.J. 2005):

- Mini étude de faisabilité: Peut-on fabriquer une voile de 1 micron d'épaisseur et 12 000 km de diamètre (diam. terrestre) ?

- Volume équivalent: diamètre 632m