

AN ENTRY LEVEL INTERFEROMETER FOR SPACE

by

P.Y. Bely, ESA, Space Telescope Science Institute, Baltimore, Md, USA.

Tel:(301)338-4780

C. Burrows, ESA, Space Telescope Science Institute, Baltimore, Md, USA.

Tel:(301)338-4913

F. Roddier, National Optical Astronomy Observatories, Tucson, Az, USA.

Tel:(602)325-9220

and **G. Weigelt**, Physikalisches Institut, Erlangen, FRG

Tel:49-91-31-857204

Observational optical astronomy is always scientifically driven to develop telescopes with fainter limiting magnitude and higher resolution. Larger ground-based telescopes are more sensitive, but give little improvement in resolution unless extremely demanding interferometric techniques are used. Space-based telescopes of traditional configuration such as the Hubble Space Telescope (HST) give great improvements in resolution being diffraction limited, and a consequent improvement in limiting magnitude, but further improvements are limited by launch constraints.

To achieve still higher resolution, interferometers are the answer. On the ground, baselines can be very large, but the atmosphere limits integration times. As a result, the science possible with the many proposed ground-based long baseline interferometers is probably limited to the vicinity of bright sources. A space-based interferometer, on the other hand, would be capable of integrations of seconds rather than milliseconds and thus could reach 16th or 17th magnitude. For example, this would allow bright quasars, Seyfert galaxies, or stellar chromospheres at Lyman alpha to be imaged at several times the resolution of HST. Furthermore, a space interferometer benefits from the "wavelength advantage". If it can be made to operate in the UV at or below Lyman alpha, a space interferometer will have four times the resolution obtained from the ground with the same baseline.

Many concepts for space-based interferometers have been proposed, but they are in general of major proportions, with baselines of 15 meters or more, and will require extensive technological development. We believe that the technical feasibility of space interferometry must be demonstrated before projects of this magnitude can be initiated. A smaller interferometer, say with a baseline on the order of 6 meters, would be less ambitious than the current generation of proposals, and might consequently limit somewhat the science on which they are based. On the other hand, it would be much lower in cost, risk, and time to develop, and would serve as a stepping stone to the larger projects. As shown in Figure 1, such an instrument would nevertheless have a significant scientific niche of its own, raising its interest much beyond the technical demonstration level.

Our proposed instrument is based on the following rationale:

- a science goal limited to high resolution imagery,
- a deliberately simple and relatively low cost design,
- a baseline of about 6 meters and a relatively good instantaneous Fourier plane coverage for satisfactory image reconstruction and time resolution (a distinctive scientific advantage over single arm interferometers),

- a Fizeau type interferometer configuration to avoid relay optics and delay lines, and to minimize the number of optical surfaces for good UV throughput,
- a sufficient field of view to permit guiding, cophasing and coalignment of the interferometer using an off-axis reference star,
- use of a sunsynchronous orbit to minimize thermal and mechanical disturbances and maximize observing efficiency,
- restricted pointing capability around the antisun direction to reduce baffling constraints,
- low mass and deployable design for compatibility with medium sized launchers.

A first attempt at realizing this concept is shown on the accompanying figures and is briefly described hereafter.

The aperture consists of eighteen 40-cm square mirrors arranged in 3 rings, with an outside diameter of 6 meters. The corresponding collecting area is equivalent to about 2 meter diameter full aperture. The individual beams are combined through a common secondary mirror and focused near the primary mirrors' common apex. To reduce cost, and ensure that all primary mirrors have the same radius of curvature, the mirrors are manufactured by replication.

As shown on Figure 2, the supporting structure is composed of a telescopic central tower and six articulated arms. These arms are braced with diagonal members for high axial rigidity. It is folded for launch and opens up for deployment very much like a collapsible umbrella. Once open, the proposed design provides nearly equal moments of inertia around the three axes, thus minimizing the attitude control requirements.

Although the proposed structure is made of low expansion material, no attempt will be made to obtain a dimensionnally stable structure, either passively (with insulation), or actively (with structural heaters). Relying on structural rigidity and the very uniform thermal environment offered by the sun synchronous orbit, an active optics system applied to the primary mirrors should be sufficient. Our proposed active optics system is composed of actuators on the 18 primary mirrors servoed to coaligning and cophasing sensing systems. The remainder of the optics is not active.

The coaligning and cophasing sensing system is non-interferometric and uses the wavefront curvature sensing concept¹. The system provides the signals to correct the tilt and piston errors of each of the primary mirrors.

The entire interferometer assembly is protected from the sun by a sun shade located on the rear of the spacecraft extending only partially up the sides. This leads to a considerable simplification of the spacecraft structure. The price to pay is that the pointing has to be limited to about 25 degrees from the anti-sun direction.

The electrical system is a traditional low-voltage solar array system. The solar arrays are fixed to avoid the low frequency excitations that a steerable system would create. They are mounted on the back of the sunshade to always be illuminated by the sun.

References:

F. Roddier, *Curvature sensing and compensation: a new concept in adaptive optics*, Applied Optics, Vol.27, no.7, p1233.

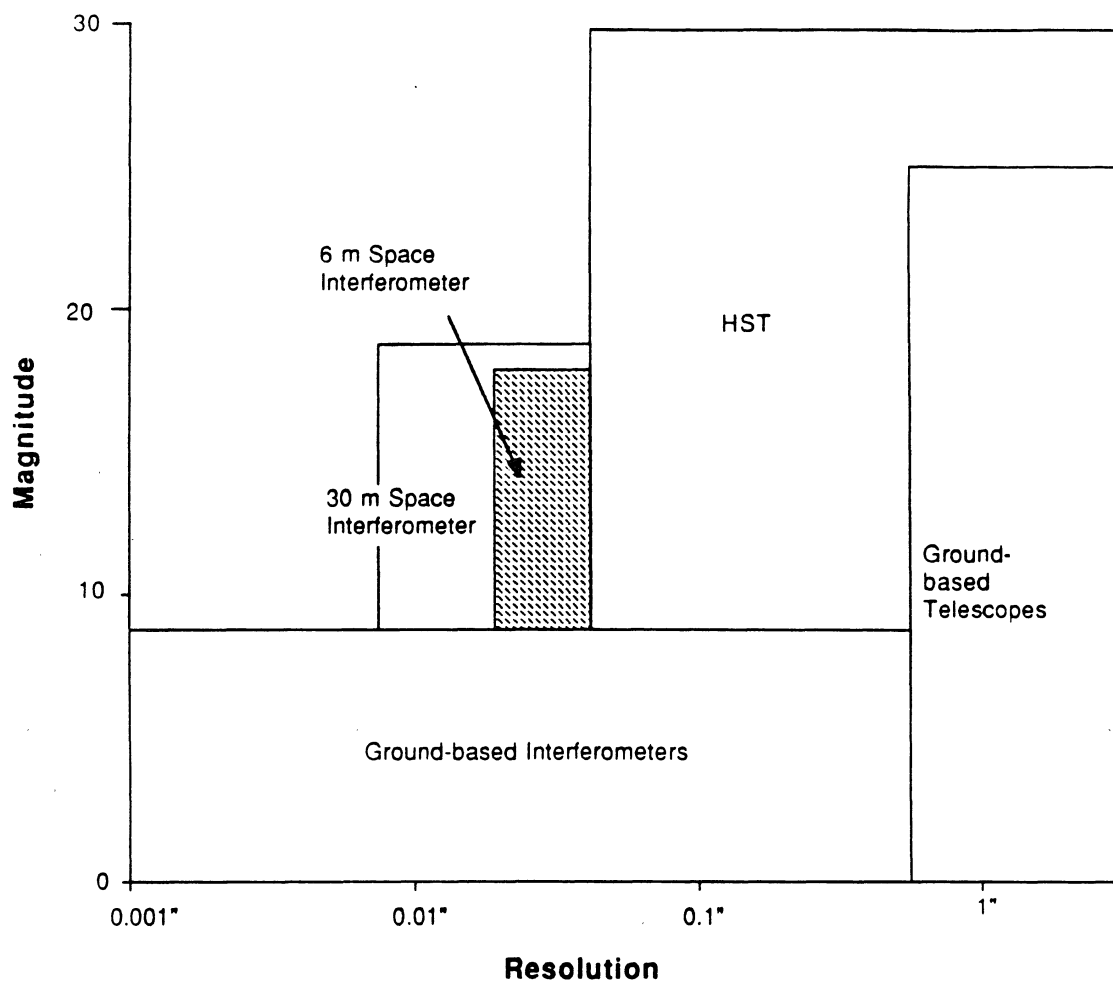


Figure 1. Domain of the proposed interferometer (hatched area) compared to that of other existing or proposed optical instruments. This diagram applies at $5000\text{\AA}$ but in the vacuum ultraviolet all space-based instrumentation can in principle improve in resolution inversely with the wavelength. If the proposed 6 meter interferometer can be made to work at $1500\text{\AA}$, the resolution would be improved to about 6 milli-arcseconds

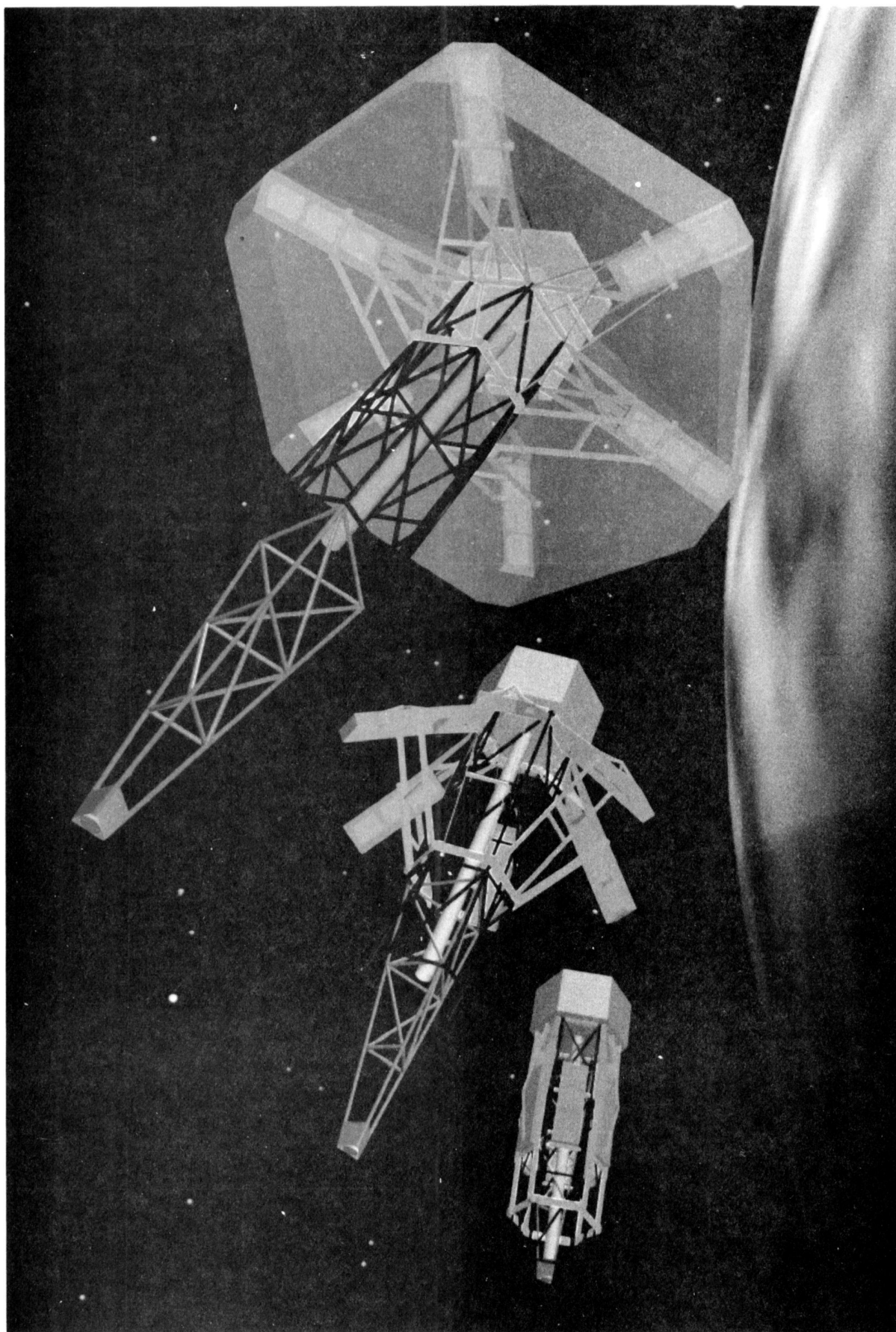


Figure 2. Artist view of the proposed interferometer during deployment.

NOTES