DETECTING DISTANT PLANETS WITH SPACE TELESCOPE

Thornton Page
NASA Johnson Space Center, Code SN
Houston, Texas 77058

ABSTRACT. In 1981 and in 1984, I offered at the University of Houston, CLC, a course on Space Telescope, the first of its kind. The 22 graduate students were assigned research projects of their own choosing designed for ST. Several chose the detection of planets of other stars, showing the popularity of the search for extraterrestrial life. Space Telescope's six instruments can be used for this purpose in several ways, and the students, most of them scientists and engineers at the NASA Johnson Space Center, proposed to use most of these after ST is launched in 1986 or 1987. The student proposals require a significant fraction of ST observing time over a period of five to ten years, indicating the over-subscription that faces the ST Science Institute. In this paper, I summarize the capability of ST instruments, and recount the techniques likely to be most effective in using them to detect planets of other stars.

1. INTRODUCTION

This paper adds little to Jane Russell's presentation. As the abstract indicates, I have been teaching a course on Space Telescope at the University of Houston in Clear Lake City. We use two NASA publications on ST (References 1 and 2) as textbooks, and Bob O'Dell (ST Principal Scientist) has been kind enough to give a lecture and help with answering technical questions. Of the 11 graduate students in the first session, two chose to write their term papers -- proposals for the use of ST -- on the search for planets of other stars. Letters from Riccardo Giacconi, Director of the ST Science Institute, encouraged the students writing their proposals.

Table 1, taken from Reference 3, shows the capabilities of the six ST instruments. Notice the remarkable spacial resolution of FOC (0.02 arcsec) and its sensitivity (28th magnitude), the spectral resolution of HRS (0.03 Å), the time resolution of HSP (16 μsec), and the relative positional accuracy of FGS (0.003 arcsec).

M. D. Papagiannis (ed.), The Search for Extraterrestrial Life: Recent Developments, 85–89.

https://doi.org/10.1017/S0074180900146388 Published online by Cambridge University Press

Table 1. Instruments on the f/24 2.4-m Ritchey-Cretien SPACE TELESCOPE

			Field	Res.	Band-pass	Limits	
WF/PC	Wide Field Camera	f/12.8	2!7 x 2!7	0"1	1150-11000Å	$9.5 \leq m_V \leq 28$mag.	
	Planetary Camera	f/30	1.2 x 1.2	0.04	1150-11000	$8.5 \leq m_V \leq 28$	
	4, 800x800 CCD detectors, 15μ square, 3 objective gratings 5-110Å/pixel						
FOC	Faint Object Camera,	f/96	11" x 11"	0"02	1200-6000Å	$21 \leq m_V \leq 28$mag.	occulting finger
		f/48	22 x 22	0.04	1200-6000	$21 \leq m_V \leq 28$	also spectra & polarimeter
	MgF_2 image intensifier, Westinghouse TV tube						
FOS	Ft Obj Spectrograph,	$R=10^3$	0"1 to 4"3	3Å	1150-7000Å	$19 \leq m_V \leq 22$mag.	polarimeter
		$R=10^2$	0.1 to 4.3	30	1150-7000	$22 \leq m_V \leq 26$	polarimeter
	SiO_2 & MgF_2 512-diode Digicon detectors, 50-μsec resolution						
HRS	Hi Res Spectrograph	$R=10^5$	0".25 to 2"0	0.03Å	1100-3200Å	$m_V \leq 11$mag.	exp$\geq$0.025sec
		$R=2x10^4$	0.25 to 2.0	0.15	1100-3200	$m_V \leq 14$	exp$\geq$0.025
		$R=2x10^3$	0.25 to 2.0	1.5	1100-1700	$m_V \leq 17$	exp$\geq$0.025
	$CsTe/MgF_2$ and CsI/LiF 512-diode Digicons, 3 blazed gratings, 1 echelle						
HSP	Hi Speed Photometer, filters		0"4, 1"0, 10"	16 μsec	1200-8000Å	$m_V \leq 24$mag.	polarimeter
	2, S-20 & 2, $CsTe/MgF_2$ photomultiplier detectors						
FGS	Fine Guidance System,	3 star selectors	69(arcmin)^2	0"003	4670-7000Å	$4 \leq m_V \leq 17$mag.	
	Koester prism interferometer and image disector						

Abbreviations used:

Res. = resolution, ' = arcmin, " = arcsec, Å = Ångstrom = 10^{-10}m, m_V = visual magnitude,

μ = micron = 10^{-6}m, μsec = 10^{-6}second, m = meter

https://doi.org/10.1017/S0074180900146388 Published online by Cambridge University Press

Table 2. Students' Proposed Uses of the SPACE TELESCOPE

Student	Objects	Total Hours Used with Instruments						Time Extent of Observations	Slew Time
		WF/PC	FOC	HRS	FOS	HSP	FGS		
Sistrunk	Asteroids		2	5				5-10 yrs, specific times	5 hr
Jernigan	Extrasolar Planets		40 per yr		2 per yr	1	5 per yr	5-10 yrs, specific times	6 per yr
Lancaster	Stars						5 per yr	15 yrs	0
Polt	Pulsars		36			7			4
Weber	Supernovae	20 per yr	40		20 per yr		5 per yr	5-10 yrs	3
Langston	Galaxies	40	40			20			10
Engle	Galaxies					10			5
Huguley	M87 Jet			20		1			1
Nealis	Extrasolar Planets		120			1	5 per yr	5-10 yrs, some specific times	7
Connell	Intergal. Medium	100		100	100				15
Greenleaf	Black Holes			30	30	40		2-4 yrs, some regular intervals	167
TOTALS		160	438	155	240	80	100	For 5 years	247

https://doi.org/10.1017/S0074180900146388 Published online by Cambridge University Press

2. PLANET DETECTION TECHNIQUES

Table 2 lists the projects proposed by the first class. (The students of the second class were somewhat less imaginative.) Jernigan and Nealis separately proposed to detect planets of other stars. Note that slew time -- the time to point ST at a new target -- adds a good many hours to ST observing time. These values are underestimates; as Ms Russell has said, ST observing time will be only about 35% of total elapsed time. Each of the proposals was presented by the author in class, and argued by all the students. The bottom line shows that 11 proposals add up to 1423 hours in five years -- 3.3% of all the ST time available. Jernigan's and Nealis' add up to 403 hours, about 1%. This emphasizes the problem of allocating time on ST! Many of the other proposals are of scientific interest, especially Greenleaf's on black holes. This feature points up another aspect of allocating fair amounts of ST time for such widely differing topics as distant galaxies (look-back times of 10 billion years), active galactic nuclei (black holes), stars and clusters of the Milky Way, search for planets of nearby stars, and solar-system studies. It is to be hoped that FGS measurements of star positions for variable proper motions of nearby stars can be undertaken while other ST instruments are observing other objects (in the serendipity mode).

The Space Telescope Institute Council (STIC) chaired by Lyman Spitzer, Jr., and the Time Allocation Committee (STAC) chaired by Jeremiah Ostriker, will have some say on which of these topics should get ST time, but the obvious tendency will be to give short-term projects higher priority than such long-term projects as searching for planets of other stars.

From the class discussion of Jernigan's and Nealis' proposals, I concluded that the best ideas for detecting Jupiter-size planets of other stars are the following (repeating the principles mentioned in David Black's paper):

2.1. Measure accurate positions of 100 nearby, late-type, single stars with FGS to detect "looping" proper motions. (Each observation is quick, but the series must go on for 5 or 10 years at 6-month intervals to detect looping.) This technique was originated by Peter Van de Kamp and Sarah Lippincott at Sproul Observatory, Swarthmore, PA. As reported in Reference 4, at least three of 20 such stars show looping.

2.2. Select those stars with "loops" in the line of sight; i.e. edge-on orbits. Use HRS to detect orbital radial velocities, possible far-red excess due to the planet, and possible changes in the absorption spectrum due to the planet's atmosphere in the line of sight.

2.3. Use HSP at the correct phase to detect eclipse of the planet or its transit across the star. HSP photometric accuracy is 2 parts in 1000, possibly adequate at 7000-8000Å.

2.4. At times of widest separation, use FOC with occulting finger blocking the star's light to detect the planet image (barely possible for a Jupiter-size planet at 10 or 20 lightyears' distance.)

https://doi.org/10.1017/S0074180900146388 Published online by Cambridge University Press

3. CONCLUSIONS

The main defect of these ideas is the long time duration involved. However, it is possible to use the last two (2.3 and 2.4) on five of the suspect stars studied from the ground to get more immediate results. I must admit that IRAS observations have easily detected three (and possibly more) planetary systems, and that SIRTF in later years may be used to detect other cometary clouds or planetary dust, if not individual planets, around nearby stars.

4. REFERENCES

4.1. "Scientific Research with the Space Telescope," Longair & Warner, NASA CP-2111, MSFC, 1979, (IAU Symposium #54), 327 pp.

4.2. "The Space Telescope Observatory," Don Hall, Ed., ST Sci Inst, NASA CP-2244, 1982 (IAU Commission 44), 134 pp.

4.3. "Space Telescope," Thornton Page, Dudley Observatory Reports, No. 16, pp. 18-41, Sept, 1982

4.4. "Stars of Variable Proper Motion," Sarah Lippincott, Space Science Reviews, 22, pp. 153-189, 1978; updated in "Status of the Sproul Astrometric Plate Series on the Nearest Stars in Search for Planetary Systems," Sarah Lippincott, Bulletin of AAS, 14, p. 627, 1982