between meteorites and aluminum. Column 3 of Table 1 gives the results of these corrections (factors of ~ 2.5 for each), and Fig. 3 presents a comparison of theory and experiment. We see from Table 1 that solar modulation has been responsible for variations from the Apollo 8 mission to the Apollo 16 mission by a factor of 5; shielding differences at different positions caused differences of a factor of ~ 2.5. These two factors thus explain the apparent discrepancy between our results and those of Benton and Henke (*9*).

The total doses of particles in the Apollo 14 and Apollo 16 command modules are higher but comparable to that in the Apollo 8 command module and presumably would cause the killing of a number of cells comparable to our calculation (*1*) for that mission. Even for the giant cells, the fraction killed is probably trivial, less than 500 cells per 10^6. However, relevant to a Mars-like mission (of ~ 2 years in duration), cellular damage would be extensive—as great as ~ 3 percent for the Apollo 16 flux level. The inadvertent reductions by a factor of ~ 2.5 in flux as a result of differences in shielding presumably could be enhanced by judicious planning and rearrangement of needed mass to provide optimum shielding at particular positions which the crew would occupy during most of a long voyage.

R. L. FLEISCHER, H. R. HART, JR.
G. M. COMSTOCK*, M. CARTER†
A. RENSHAW

General Electric Research and Development Center, Schenectady, New York 12301

A. HARDY

NASA Manned Spacecraft Center, Houston, Texas 77058

References and Notes

1. G. M. Comstock, R. L. Fleischer, W. R. Giard, H. R. Hart, Jr., G. E. Nichols, P. B. Price, *Science* **172**, 154 (1971).
2. E. C. McKannan, A. C. Krupnick, R. N. Griffin, L. R. McCreight, *NASA Tech. Memo X-64611* (July 1971); see also *Chem. Eng. News* (25 January 1971), p. 25.
3. R. L. Fleischer and H. R. Hart, Jr., in *Apollo 16 Preliminary Science Report* (National Aeronautics and Space Administration, Washington, D.C., 1973); *Phys. Rev. Lett.* **30**, 31 (1973).
4. P. Todd, *Radiat. Res.* **7** (Suppl.), 196 (1967).
5. P. B. Price and R. L. Fleischer, *Annu. Rev. Nucl. Sci.* **21**, 295 (1971).
6. R. L. Fleischer, H. R. Hart, Jr., W. R. Giard, *Science* **170**, 1189 (1970).
7. D. D. Peterson, *Rev. Sci. Instrum.* **41**, 1254 (1970).
8. The Apollo 8 and Apollo 12 values are higher by a factor of 2 than the values quoted previously (*1*) because of a corrected computation of the solid angle factor.
9. E. V. Benton and R. P. Henke, *U.S. Air Force Weapons Lab. Rep. AFWL-TR-72-5* (June 1972); *Univ. San Francisco Tech. Rep. 20* (Aug. 1972).
10. W. T. Crawford, W. DeSorbo, J. S. Humphrey, *Nature* **220**, 1313 (1968); D. D. Peterson, thesis, Rensselaer Polytechnic Institute (1969) [summaried in P. B. Price and R. L. Fleischer, *Radiat. Eff.* **2**, 291 (1970)]; E. V. Benton, R. P. Henke, H. H. Heckman, *Radiat. Eff.* **2**, 269 (1970).
11. H. J. Schaefer, E. V. Benton, R. P. Henke, J. J. Sullivan, *Radiat. Res.* **49**, 245 (1972).
12. E. V. Benton and R. P. Henke, paper presented at the 7th International Colloquium on Corpuscular Photography and Visual Solid Detectors, Barcelona, Spain, July 1970.
13. G. M. Comstock, C. Y. Fan, J. A. Simpson, *Astrophys. J.* **146**, 51 (1966); T. Saito, *J. Phys. Soc. Jap.* **30**, 1535 (1971); W. R. Webber, S. V. Damle, J. Kish, *Astrophys. Space Sci.* **15**, 245 (1972); E. Julinsson, P. Meyer, D. Müller, *Phys. Rev. Lett.* **29**, 445 (1972).
14. R. L. Fleischer, P. B. Price, R. M. Walker, M. Maurette, *J. Geophys. Res.* **72**, 333 (1967).
15. We thank M. V. Doyle for calling our attention to the electrophoresis experiment, R. Griffin and L. R. McCreight for loan of the electrophoresis experiments, W. Eichelman for necessary information, and G. E. Nichols and E. Stella for experimental assistance. This work was supported in part under NASA contract NAS 9-11486.

* Present address: Centre National pour la Recherche Scientifique, Orsay, France.
† Present address: Central State College, Wilberforce, Ohio.

23 March 1973; revised 4 May 1973

Temporal Constancy of Zodiacal Light

Abstract. *Measurements over a 4-year period from the satellite OSO-5 have failed to show any temporal variations in the surface brightness and polarization of zodiacal light.*

The zodiacal light is a faint glow of light along the zodiac (or ecliptic) produced by the scattering of sunlight by particles in the solar system. Our satellite observations undertaken to search for temporal changes in the brightness have revealed a remarkable constancy of the phenomenon. Observations of the surface brightness and polarization of the zodiacal light had been made for many years without apparent convergence between the results obtained by different workers (*1*). An evaluation of ground-based measurements of the surface brightness of zodiacal light at the north ecliptic pole shows a range of more than a factor of 3 in the values obtained by different observers (*2*), and variations of a factor of 2 sometimes occur in the results of a single group (*1*). It is therefore difficult, and virtually meaningless, to intercompare the observations for an indication of temporal changes in zodiacal light, while the magnitude of the variations in a single set of data makes it difficult to credit small changes reported from such results. Nevertheless, many papers have been written on the variations of zodiacal light intensity, at constant ecliptic coordinates, over periods of days and years; these purport to show evidence for a correlation between the surface brightness and magnetic storms, lunar phase, the position of Comet Encke, an annual cycle, and the 11-year solar activity cycle.

During the last few years measurements from balloons (*3, 4*), rockets (*5, 6*), and satellites (*7–10*) have begun to reduce the inconsistency between different observations of zodiacal light. Balloon observations eliminate the need to subtract the contribution to the measured light made by the tropospheric scattered component; a comparison of satellite and ground-based measurements indicates that the latter generally suffer from a systematic positive error, perhaps due to incorrect subtraction of the component scattered in the earth's atmosphere (*8*). Measurements above about 150 km further eliminate most of the problems of airglow subtraction, although airglow cannot be entirely discounted above this altitude (*2, 7*), and it has been measured during one zodiacal light experiment from a satellite (*11*). A single rocket (or balloon) experiment cannot attempt to define temporal changes in the zodiacal light; however, an experiment on a satellite is in a unique position to do so.

The Minnesota experiment on the Orbiting Solar Observatory satellite OSO-5 has made it possible to compare measurements of the surface brightness and polarization of the zodiacal light with a single instrument over a time span of years. The satellite was launched in January 1969 and turned off in January 1973. During that 4-year period observations were taken throughout most of the new moon periods until the moon, if risen, was within 50° of the field of view of the photometers. A description of the experiment has been published (*12*).

Several observers have reported changes in the zodiacal light associated with magnetic activity. A measure of the magnetic disturbances at the earth are the geomagnetic indexes *Kp* and Σ*Kp*. Blackwell and Ingham (*13*) correlated an increase in the surface brightness of the zodiacal light with *Kp* (the planetary 3-hour range index) during a strong magnetic storm in July 1958; Asaad (*14*) found a decrease in the surface brightness with ΣKp (the daily sum of the Kp values), although the degree of polarization showed an increase. He attributed this change to the effect of the solar wind or to alignment of particles by the interplanetary magnetic fields. We consider it more likely that any change in zodiacal light attributable to solar flare effects would be due to Thomson scattering from the increased interplanetary electron density occurring at these times. Such changes should be more readily apparent in the polarized component of the zodiacal light, where one does not have to overcome the errors associated with removal of the integrated starlight from the measured surface brightness.

During the period 1969 to 1973, we have failed to find any change in the polarized component (or in the surface brightness) of the zodiacal light that we could attribute to solar activity; this interval included 20 magnetic storms with $\Sigma Kp > 30$ at times when a comparison was possible. One of the storms (in August 1972) was reported to be due to the largest flare in the current solar activity cycle (*15*). During this storm no changes in the polarized component of the zodiacal light were observed to a limit which corresponds to a change in the electron density of 3 cm^{-3} in a plasma cloud of thickness 1 A.U. This limit is not far above that detected in a number of the sudden electron density changes reported from the Stanford radio propagation experiments with Pioneer 7 (*16*). The values of the intensity of the polarized component measured during the period 25 July to 12 August 1972 are shown in Fig. 1. The index ΣKp reached 60 on 5 August. There is no evidence of significant changes associated with either the magnetic storm or the lunar cycle (the new moon was on 9 August).

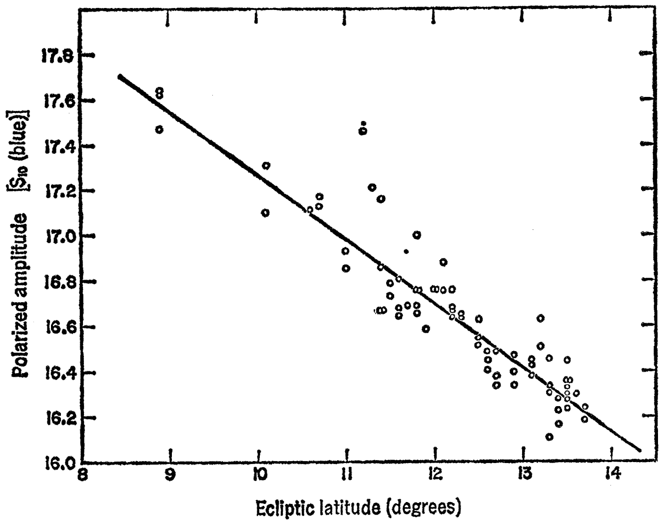

Fig. 1. Polarized amplitude of zodiacal light in units of brightness of magnitude 10 stars per square degree [S_{10} (blue)] as a function of ecliptic latitude, at a constant ecliptic longitude of 90°, measured during the period 25 July to 12 August 1972. The index ΣKp was 50, 60+, and 47— on 4, 5, and 6 August. The new moon was on 9 August.

Since Fesenkov (*17*) suggested the possible existence of a circumterrestrial dust cloud some 50 years ago, the subject has remained somewhat controversial. The existence of such a cloud has been used to explain the correlation found between lunar phase and zodiacal light intensity (*18*) and between the position of the axis of zodiacal light and the ecliptic latitude of the moon (*19*). In order for such correlations to be real, the bulk of the dust responsible for the zodiacal scattering must be situated within the earth-moon gravitational system. Gillett (*3*), from observations made by OSO-2, found that he could not detect a contribution to the zodiacal light by a geocentric cloud to the limit of the equivalent visual brightness of two magnitude 10 stars per square degree [$2S_{10}(V)$]. This result is confirmed by the observations made by OSO-5.

Variations of zodiacal light over longer periods have been suggested by Fracassini and Pasinetti (*20*), who reported that it was possible to correlate them with the number of comets that appeared each year and their total absolute magnitude. Huruhata (*21*) had earlier found a yearly variation of the brightness of zodiacal light coupled to the position of Comet Encke. This comet has been credited by Whipple (*22*) with being the major factor in maintaining the quasi-equilibrium of the zodiacal cloud. During the passage of the earth through the node of the comet in 1969, Roosen (*23*) observed what he took to be the earth's shadow visible in the center of the gegenschein, which he ascribed to an enhancement of the dust near the earth. He suggested that a confirmation of the observation might be possible during the earth's passage through the orbit plane of the comet in February 1971 (*24*). Fracassini and Pasinetti (*25*) also compared measurements of the brightness of zodiacal light made by various observers at different times, and concluded that the brightness is probably enhanced near the maximum of solar activity. Weinberg (*1*) suggested that the results reported over the period 1950 to 1967 do appear to indicate a relation

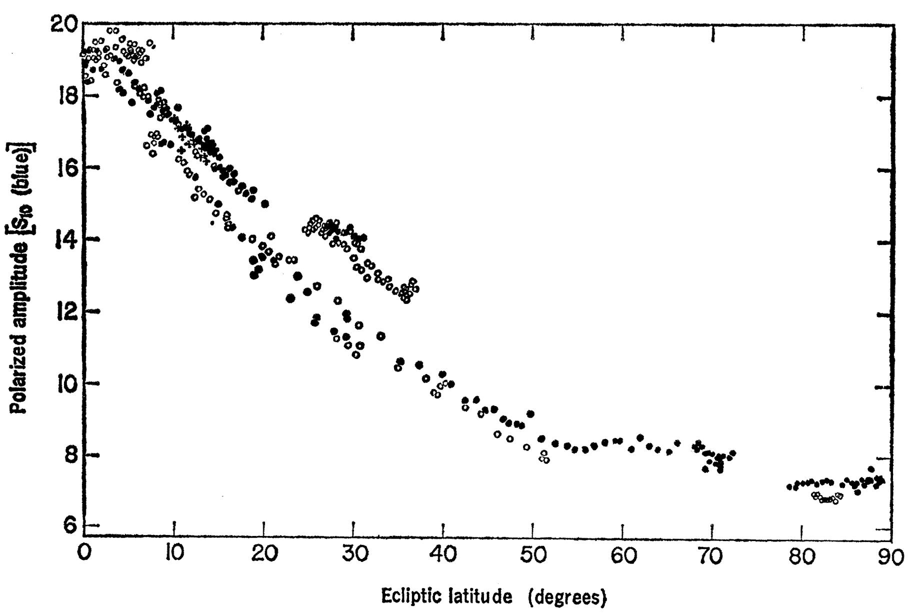

Fig. 2. Polarized amplitude of zodiacal light in units of [S_{10} (blue)] as a function of ecliptic latitude, at a constant ecliptic longitude of 90°, measured during the 4-year period 1969 to 1973. (Open circles) Southern ecliptic hemisphere; (filled circles) northern ecliptic hemisphere; (crosses) observations during the new moon period in August 1972. The two groupings of points do not indicate a variation. They are produced by small uncertainties in our knowledge of the orientation of the telescopes.

between the solar cycle (indicated by relative sunspot number) and zodiacal light brightness.

The photometers on OSO-5 were directed at a constant ecliptic longitude (90° ± 4°) but various ecliptic latitudes, generally within 35° of the ecliptic, although excursions were made to both the north and south ecliptic poles. Measurements made at the same ecliptic latitudes (in both hemispheres) but at different times over the 4-year period failed to show differences in brightness or polarization that were greater than the limits of accuracy of the determinations (± 10 percent, in general) as shown in Fig. 2. No evidence for the influence of Comet Encke has been obtained. Nor has any north-south asymmetry been measured, although the rocket observations of Wolstencroft and Rose (*6*) had suggested that the brightness of the south pole exceeded that of the north pole by about 15 percent (at the time of observation), which they interpreted as possibly indicative of the motion of the earth with respect to the invariant plane.

Any temporal changes in the brightness and polarization of zodiacal light appear to be below the accuracy limit of the OSO-5 experiment. However, the next generation of satellite-borne zodiacal light probes may yield information on any changes of lesser magnitude (*10, 26*).

J. G. SPARROW*, E. P. NEY
School of Physics and Astronomy, University of Minnesota, Minneapolis 55455

References and Notes

1. J. L. Weinberg, in *Space Research*, T. M. Donahue *et al.*, Eds. (North-Holland, Amsterdam, 1970), vol. 10, p. 233.
2. R. D. Wolstencroft and F. D. Roach, *Astrophys. J.* **158**, 365 (1969).
3. F. C. Gillett, in *Zodiacal Light and the Interplanetary Medium*, J. L. Weinberg, Ed. (NASA SP-150, National Aeronautics and Space Administration, Washington, D.C., 1967), p. 9.
4. E. L. Van de Noord and V. H. Regener, *Astrophys. J.* **161**, 309 (1970).
5. C. F. Lillie, thesis, University of Wisconsin (1968).
6. R. D. Wolstencroft and L. J. Rose, *Astrophys. J.* **147**, 271 (1967).
7. C. F. Lillie, in *Scientific Results from the Orbiting Astronomical Observatory (OAO-2)*, A. D. Code, Ed. (NASA SP-310, National Aeronautics and Space Administration, Washington, D.C., 1972), p. 95.
8. F. E. Roach and C. F. Lillie, in *ibid.*, p. 71.
9. J. G. Sparrow and E. P. Ney, *Astrophys. J.* **154**, 783 (1968); *ibid.* **174**, 705 (1972).
10. J. L. Weinberg, M. S. Hanner, H. M. Mann, P. B. Hutchison, R. Fimmel, paper presented at the 15th COSPAR plenary meeting, Madrid, Spain, 1972.
11. J. G. Sparrow, E. P. Ney, G. B. Burnett, J. W. Stoddart, *J. Geophys. Res.* **75**, 5475 (1970).
12. G. B. Burnett, J. G. Sparrow, E. P. Ney, *Appl. Opt.* **11**, 2075 (1972).
13. D. E. Blackwell and M. F. Ingham, *Mon. Not. Roy. Astron. Soc.* **122**, 143 (1961).
14. A. S. Asaad, *Nature* **214**, 259 (1967).
15. P. S. McIntosh, *Sky Telesc.* **44**, 214 (1972).
16. R. L. Koehler, *J. Geophys. Res.* **73**, 4883 (1968).
17. V. G. Fesenkov, *Sov. Astron. AJ* **15**, 143 (1971).
18. N. B. Divari, *ibid.* **7**, 547 (1964).
19. ——— and N. I. Komarnistkaya, *ibid.* **9**, 632 (1966).
20. M. Fracassini and L. E. Pasinetti, *Mem. Soc. Astron. Ital.* **37**, 267 (1966).
21. M. Huruhata, *Publ. Astron. Soc. Jap.* **2**, 156 (1951).
22. F. L. Whipple, in *Zodiacal Light and the Interplanetary Medium*, J. L. Weinberg, Ed. (NASA SP-150, National Aeronautics and Space Administration, Washington, D.C., 1967), p. 409.
23. R. G. Roosen, *Icarus* **13**, 184 (1970).
24. B. G. Marsden, *Int. Astron. Union Circ. No. 2266* (1970).
25. M. Fracassini and L. E. Pasinetti, *Mem. Soc. Astron. Ital.* **36**, 199 (1965).
26. M. S. Hanner and C. Leinert, in *Space Research*, T. M. Donahue *et al.*, Eds. (North-Holland, Amsterdam, 1970), vol. 12, p. 445.
27. This research was supported by NASA contract NAS 5-3838.
* Present address: Aeronautical Research Laboratories, Department of Supply, Box 4331, P.O. Melbourne, Victoria, Australia 3001.

1 March 1973; revised 13 April 1973

Evidence for Fetal Antigen in Human Sarcoma

Abstract. A common antigen (S_2), initially thought to be uniquely associated with human sarcomas, has been found to be widely distributed in patients with other tumors as well. Absorption studies with human embryonic tissues suggest that S_2 may be a fetal antigen. The presence of antibody to S_2 in patients with tumors and in their relatives implies a propensity in these individuals for cellular dedifferentiation which may be a prerequisite for malignant transformation.

A diffuse cytoplasmic antigen, specific to human sarcomas, has been described by Morton and Malmgren (*1*) and Priori *et al.* (*2*) in acetone-fixed tumor cells tested by an indirect immunofluorescence technique. Antibody to this antigen has been demonstrated in a high percentage of serums from patients with various histologic types of sarcomas, their family members, and close associates. In contrast, few serums from normal individuals have been found to react against the same antigen. Type C virus particles were also reported by both groups in cells said to be positive for the sarcoma antigen (*2, 3*). These observations have been cited as indirect evidence for an infectious, possibly viral etiology of human sarcomas. We have identified an antigen in human sarcomas which closely resembles and probably is identical to the antigen described by Morton and Malmgren and by Priori *et al.* An extensive effort to characterize the antigen and determine its distribution among patients with cancer has been undertaken. Results to date indicate that while the earlier serologic findings can be confirmed, neither the antigen nor antibody directed against it has as limited a distribution as the first reports suggested. This diminishes the likelihood that the antigen is associated with an etiologic agent responsible for a specific type of cancer.

Monolayer cell cultures were maintained in Eagle's minimum essential medium with 10 percent fetal calf serum. For testing, cultures were trypsinized and the cells were placed on glass slides with eight antigen wells. The slides were incubated at 37°C for 24 to 48 hours to permit cells to attach and spread, and the cells then were fixed with acetone. Indirect immunofluorescence tests were carried out after the method of Goldman (*4*). Details of this procedure have been published elsewhere (*5*).

Initially we had considerable difficulty in demonstrating this antigen, since it is often manifest only as a low-intensity, diffuse fluorescence. However, in a comparison of the reactivity of serums from sarcoma patients with that of normal serums when applied to the same antigen on adjacent wells of a single slide, significant differences became apparent. A positive reaction is seen in Fig. 1A. The majority of cells show a diffuse cytoplasmic fluorescence with perinuclear accentuation. Normal serums persistently failed to elicit any cytoplasmic fluorescence; instead, they often produced a nuclear fluorescence (Fig. 1B), while the saline controls showed no fluorescence at all. The nuclear fluorescence is thought to be due to nonspecific absorption of serum globulins to the fixed nuclei. The brightest cytoplasmic fluorescence was seen in cells derived from benign giant cell tumors of bone.

An earlier report by Giraldo *et al.* (*6*) indicated that another antigen was present in cultured sarcoma cells characterized morphologically by a punctate cytoplasmic distribution. This has subsequently been referred to as