Hamiltonian. Then Eqs. (2) and (7) must also be antisymmetrized. Physically we have neglected the possibility that there is single-particle strength in χ_0 or, in other words, that the single-particle state, φ_n, is partly occupied. The consequences to the sum rule (5) and the relation (9) are what might be expected. The sum rule must give $1-\Lambda$ instead of unity, where Λ is an exchange integral giving the single-particle strength already contained in χ_0. With a reasonable approximation, similar to that used for the other bound states, the denominator in Eq. (9) should be replaced by $1-\sum S_q-\Lambda$.

To conclude, we can say that the insertion of a complete set of states has led to the useful sum rules (5). The new stripping theory can be understood as relating the "single-particle stripping strengths" of a bound state and the continuum.

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†On leave from Theoretical Physics Div., Atomic Energy Establishment, Harwell, Didcot, Berkshire, England.

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[2] The functions can be obtained by writing the sum rule in terms of the $\Psi^{(-)}$, using the standard relationships between the $\Psi^{(-)}$ and $\Psi^{(+)}$, and finally inverting a matrix.

TWOFOLD INCREASE OF THE HIGH-ENERGY X-RAY FLUX FROM CYGNUS XR-1†

James W. Overbeck and Harvey D. Tananbaum
Physics Department and Laboratory for Nuclear Science,
Massachusetts Institute of Technology, Cambridge, Massachusetts

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In a series of measurements using a balloon-borne scintillation counter we have found a significant change in the high-energy (>23 keV) x-ray flux from Cygnus XR-1. On 16 and 25 May 1967 we flew the same detector with which we had measured the spectrum of Cygnus XR-1 from 23 to 97 keV on 19 September 1966. These two May observations were in agreement with each other and were about twice the magnitude of the result reported earlier by us.[1]

There have been earlier reports of a decrease by a factor 3-6 in the 1- to 10-keV x-ray flux from Cygnus XR-1[2-4] relative to the early (self-consistent but unconfirmed) June 1964 measurement by Bowyer et al.[5]

In Ref. 1 we compared our September 1966 data with McCracken's[6] April 1965 data and found the flux he measured to be 1.5 times what we measured and to be greater than ours with at least 97% confidence. Among the reasons why such differences are not usually considered to be significant are the following: (a) Calculations, rather than measurements, of detectors' absolute sensitivity are usually used; (b) pressure altitudes are often not measured precisely and atmospheric absorption corrections are therefore subject to error; (c) malfunctions occur during flight, often with uncertain effects on the results; (d) experimenters do not agree on the correct way to analyze data.

The present comparison of our May 1967 and September 1966 results is not affected by the first problem or the last. In addition, while our September 1966 results contained a possible 15% uncertainty due to discrepancies in pressure measurements, the 16 May experiment included an in-flight comparison of a carefully calibrated pressure sensor with a Winzen barocoder like that relied on in September and consistently showed a negligible difference of 0.05 mbars.

During our May 1967 flights several malfunctions did occur; however, we believe that they produced no unknown effects on our results. These were the following: (a) complete loss of data for one energy band due to failures in the data recording system but not in the detector or amplifiers, (b) corona discharge during a well-defined part (excluded here) of the 16 May flight (stable background levels with normal statistical fluctuations before and after our Cygnus measurements give us confidence in the validity of our results), (c) interference between the orientation and command systems on 25 May which made it advisable to point at x-ray sources only momentarily and then let the balloon's rotation provide scans of the Cygnus region, and (d) failure of the on-board tape recorder on 25 May which required us to record orientation and counting-rate data on different media by telemetry (a pulse was telemetered for each count in the 23.4- to 46.7-keV band, and also the counting rate in this band integrated over 1 min was telemetered). After 23 h sidereal time on 25 May the recording of rapid changes of orientation was not accurate enough to allow us to fit the sharp peaks in the counting rate. We believe, however, that the standard deviations we present here are greater than the limits of error due to orientation errors, which occurred during relatively short periods of time.

The uppermost curve in Fig. 1 shows the counting rate in the 23.4- to 46.7-keV band averaged over 2-min intervals. The middle curve is the best fit to the data above it of the hypothesis that Cygnus XR-1 was the source of the x rays. This curve is a function of two parameters which are least-squares fitted to the data. The first parameter is the constant background counting rate (four counts per second in this case) that one finds when the x-ray source is outside the field of view. The second parameter is the number of counts per second due to the source if the detector were pointing straight at it. This is the amplitude of the time-varying part of the counting rate. Its time variation is determined by the width and the irregular scanning motion of the detector's field of view. The lowest curve shows the time behavior expected if all the x rays had come from Cygnus X-3, a candidate for the hard x-ray source in Cygnus suggested by its discoverers, Giacconi *et al.*[7,8] We cannot exclude a contribution from Cygnus X-3 that is about 0.1 times that of Cygnus XR-1.

In the 25 May flight we viewed the Cygnus region with the detector fixed at three different zenith angles: 24°, 32°, and 37°, and have analyzed these as three independent sets of data. Table I presents much of the relevant data we have obtained including actual counting rates and correction factors. The good agreement with one another of the four 23.4- to 46.7-keV fluxes found in May 1967 supports the validity of our procedure for correcting for atmospheric absorption. Their mean value is 2.3 ± 0.3 times the flux we found for the same energy band in September 1966.

One obvious difference between September and May is the large background reduction achieved in May. This was done using electronic pulse-shape discrimination to reject counts due to Cherenkov light made by electron-positron pairs produced within our light pipe. The pulse-shape distinction is possible because of the 0.25-μsec decay time of the light pulses made by x-rays in the sodium-iodide crystal, contrasted with the much faster Cherenkov light pulses whose apparent duration (<0.1 μsec) is determined by the electronics. These pulse-shape considerations are independent of the x-ray collimator (8.4° characteristic width), sensitive area (56.3 cm^2), crystal thickness (0.1 cm), and x-ray absorbing materials in front of the crystal, which are the major determinants of detector sensitivity. Further-

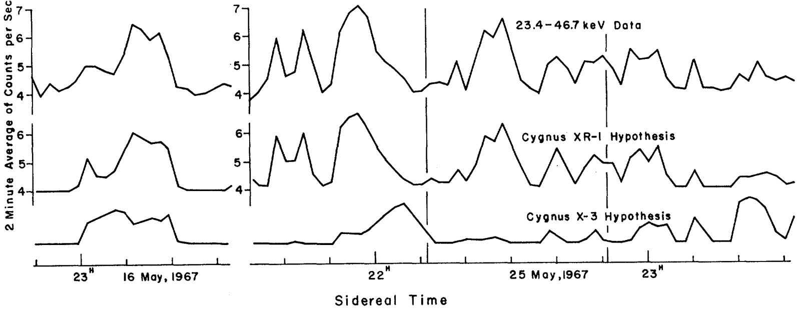

FIG. 1. Uppermost curve: observed counting rate versus sidereal time. Statistical errors may be deduced from the fact that the rate is averaged over 2-min intervals for presentation purposes. Lower curves: predicted counting rates based on the motion of the detector's field of view and an assumed cosmic x-ray source.

Table I. Experimental data on Cygnus XR-1.

Flight date	Energy band (keV)	a	b	c	d	e
16 May 1967	23.4- 37.5	2.25	2.67	3.29	3.57	0.0101 ± 0.00134
16 May 1967	37.5- 54.2	2.15	2.50	3.29	2.50	0.0057 ± 0.00059
16 May 1967	66.5-101.0	1.00	3.95	3.29	3.26	0.0017 ± 0.00060
16 May 1967	23.4- 46.7	3.54	4.15	3.29	3.27	0.0088 ± 0.00075
25 May 1967	23.4- 46.7	3.28	4.08	3.59	3.58	0.0090 ± 0.00068
25 May 1967	23.4- 46.7	2.73	4.10	3.87	3.88	0.0081 ± 0.00098
25 May 1967	23.4- 46.7	2.74	4.14	4.28	4.40	0.0091 ± 0.00146
19 September 1967	23.4- 46.7	1.30	7.83	3.83	3.84	0.0038 ± 0.00046

[a] Counts per second due to Cygnus XR-1 if pointed straight at it.

[b] Background counts per second.

[c] Atmospheric depth along line of sight (g/cm^2).

[d] Ratio of photons per second at top of atmosphere to counts per second, taking into account attenuation by atmosphere and polystyrene foam, detector efficiency, iodine K x-ray escape, and resolution (see Ref. 1). An incident spectrum of the form $AE^{-\alpha}$ was assumed, with $\alpha = 1.75$. Taking $\alpha = 2.0$, for example, changes these ratios by about 2.5%.

[e] Photons /cm^2 sec keV at top of atmosphere averaged over the energy band.

more we have found by direct measurements that legitimate x-ray counts are not rejected by the pulse-shape discriminator. Our in-flight calibrations with Au^{195} showed that the Cherenkov light rejection and the charged particle anticoincidence requirement did not affect the detector's sensitivity to x rays, which was the same in flight as on the ground. They also showed less than 1% gain change during flight. This stability is partly due to the smallness of the temperature variation (15°F) of detector and electronics in all our flights.

Figure 2 shows most of the results on the spectrum of Cygnus XR-1 for the energy range we have investigated. It shows good agreement between our September 1966 results and results obtained by Peterson *et al.*[9] and Clark, Lewin, and Smith[10] at nearly the same time. While some of the differences in Fig. 2 might be explained by detector and electronic properties or by atmospheric absorption effects, we think these are ruled out for our data by calibrations with good energy resolution (Ref. 1, Fig. 5) and by precise pressure measurements allowing accurate correction to the top of the atmosphere.

We feel that the data are still too meager to allow us to explain the cause of the observed increase, but this first observation of a flux increase (rather than decrease) rules out anything so simple as a single explosion followed by cooling. The short time in which the increase occurred implies that a significant part of Cygnus XR-1 is very probably smaller than 1 light year, the size of the Crab Nebula x-ray source. This is interesting because the spectra of the Crab Nebula and Cygnus XR-1 have been found by Clark, Lewin, and Smith[10] to be very similar.

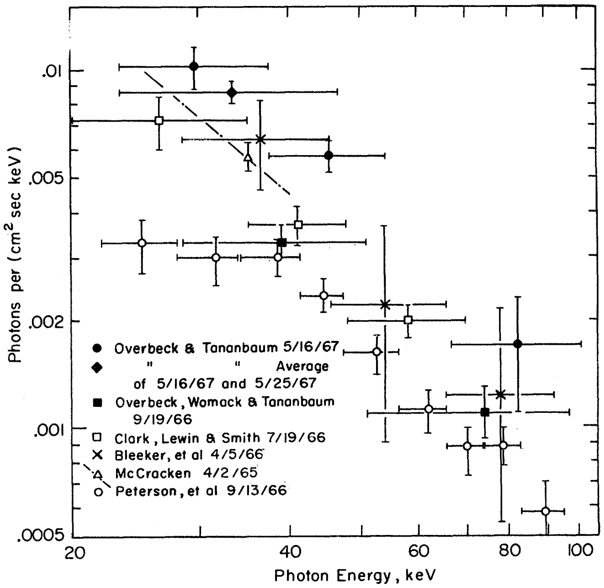

FIG. 2. Differential number spectra of the x rays from Cygnus XR-1. For our data the ordinate is the average flux (over the energy band indicated) that would be measured at the top of the atmosphere if the spectrum there had the form $AE^{-1.75}$. The abscissa is the energy at which the flux equals its average value over the band. [Crosses denote the experiment of 5 April 1966 described by J. A. M. Bleeker *et al.*, Astrophys. J. 147, 391 (1967); other data from Refs. 1, 6, 9, and 10.]

The results of a more thorough treatment of the data presented here will be published later along with data on other sources obtained during these flights and a later flight on 27 June 1967.

We are very grateful to the staff of the National Center for Atmospheric Research station at Palestine, Texas, for their hospitality and their successful conduct of the balloon flight operations. Philip Morrison and Allen Womack helped to improve the clarity of this paper.

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REGGE CUTS IMPLY VANISHING TOTAL CROSS SECTIONS OR ESSENTIALLY CONSTANT DIFFRACTION PEAKS*

J.-L. Gervais† and F. J. Ynduráin‡
Department of Physics, New York University, New York, New York

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It is shown that the infinite sequence of Regge cuts previously found in perturbation theory leads to high-energy behavior of scattering amplitudes with a power of the energy that is independent of the momentum transfer whenever the total cross sections are asymptotically constant.

It seems now well established that repeated exchange of Regge poles generates cuts in the complex angular-momentum plane.[1] If the intercept of the Pomeranchuk trajectory is strictly equal to 1, then exchange of several Pomeranchuk poles and a given trajectory $\alpha(t)$ leads to an infinite number of branch points that in general accumulate[2] for any $t<0$, at $\alpha(0)$. Up to now the current opinion seemed to be that nothing could be said about the corresponding contribution to the high-energy behavior. Nevertheless, we are going to show that, if one takes all the cuts into account, then, and for any $t<0$, the scattering amplitude $T(s,t)$ behaves asymptotically like $s^{\alpha(0)}(\ln s)^{\beta(t)}\cdots$, i.e., with a power that is independent of t, irrespective of whatever the value of the jumps over the cuts may be. For definiteness, we will present the explicit analysis for the case when $\alpha(t)$ is the Pomeranchuk trajectory itself, and later on comment on other cases.

(1) Pomeranchuk trajectory.—Here, the exchange of n Pomeranchuk poles gives a cut with a branch point located at

$$\alpha_c^{(n)}(t)=n\alpha_{\rm P}(t/n^2)-n+1. \qquad (1)$$

Since we assume, as usual, that $\alpha_{\rm P}(0)=1$, it is then clear that for any $t<0$ one has[3]

$$\lim_{n\to\infty}\alpha_c^{(n)}(t)=\alpha_{\rm P}(0)=1. \qquad (2)$$

Accordingly, the contribution of such cuts to the scattering amplitude in the s channel is, at high energy, of the form

$$\int_{-1/2}^{1}dl\,s^l g_t(l)\simeq T(s,t), \qquad (3)$$

where $g_t(l)$ is essentially proportional to the product of the signature factor times the sum of the jumps across the cuts. We remark that by virtue of (2), $g_t(l)$ cannot vanish identically in any interval $1>l>1-\delta_0$, $\delta_0\neq 0$ fixed, for any $t<0$. The desired result will be proved rigorously from formula (3) by reducing the