prehistoric man's seasonal time-keeping, my article suggests that astrology evolved as a societal mechanism by which the priests could control and manipulate their citizens.

Unfortunately, the psychological dangers of astrology have been almost totally unrecognized and virtually never studied, so there are few "hard data" to cite. In my forthcoming book for Prometheus Press, *Astrology Disproved*, I attempt to remedy this situation, as well as build on the case for the ancient "art" as a means by which the priests awed their citizens and convinced them to work together for the good of the state.

Indeed, there is much that is not generally recognized about astrology; some of the historical and psychological aspects are startling, if not frightening. The fact that astrology is becoming so popular today should alarm scientists and rational people in all walks of life, for it indicates that the ancient magic can still influence and manipulate "modern" minds.

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Highly charged quarks?

An article by the late Professor Heisenberg (March, page 32) discusses various approaches that are being pursued to determine the fundamental nature of matter.

Heisenberg criticizes the presently popular approach in theoretical particle physics, which is based on the well-known quark model. He states that, in his opinion, the quark hypothesis is not really taken seriously today by its proponents. Questions dealing with the statistics of quarks, the forces that keep them together, the reason why the quarks are never seen as free particles, the creation of pairs of quarks inside an elementary particle, are all left more or less undefined. If the quark hypothesis is really to be taken seriously, it is necessary to formulate precise mathematical assumptions for the quarks and for the forces that keep them together and to show, at least qualitatively, that all these assumptions reproduce the known features of particle physics.

This author would certainly not wish to disagree with the above. It may, however, be worthwhile to point out that attempts have been made in the past to construct modified quark theories that might satisfy Heisenberg's requirements. Perhaps the clearest or most precisely formulated of these are two theories published by Julian Schwinger and the author.[1,2] They are similar but were proposed independently. In the former theory it is assumed that "quarks" are highly magnetically charged; in the latter they are assumed to be highly electrically charged. In both theories the Coulomb attraction between charges of opposite sign or polarity is taken to be the

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quark binding mechanism, and there are no problems encountered with statistics. The normal nuclear force is assumed to be due mainly to virtual-pion (that is, quark-pair) exchange in the usual way.

It is possible that the highly-ionizing cosmic ray particle with unusual characteristics that was detected recently by a Berkeley-Houston group (see October 1975, page 17) may be one of these highly charged "quarks". When the data for this event are completely calibrated this possibility will be able to be considered in detail. Of course the negative results of searches for monopoles in other cosmic ray experiments render it much more probable that the Berkeley-Houston particle carries electric rather than magnetic charge.

At the present time it is evident that if quarks are highly charged then they must also be quite massive, because otherwise they would surely have been detected already in numerous bubble chamber experiments. This suggests that the recently discovered heavy resonances (J, ψ, χ, upsilon and others) may be the lightest radial excitations of bound quark states.

In any case it seems that the existence of testable alternatives to the fashionable quark model, which at least attempt to satisfy Heisenberg's requirements, could be usefully brought to the attention of experimentalists, including those who will be engaged in particle searches at the new accelerators such as PETRA or ISABELLE. It is hardly necessary to add that searching for highly charged particles (either magnetically or electrically charged) is much easier than searching for fractionally charged particles.

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2. P. C. M. Yock, Physical Review **D13,** 1316 (1976).

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More on Mercury's satellite

In his March letter (page 12) Bruce Bushman, quoting Isaac Asimov, offers an explanation of the fact that Mercury has no satellites. In essence, the argument is that outside of Mercury's Roche limit—2.44 times its radius—the gravitational force of the Sun is much greater than is that of Mercury, and hence a satellite in such an orbit cannot be stable. Inside the Roche limit, of course, the satellite would be broken up by the tidal effects of the planet.

Asimov considers the ratio $(M_1/R_1^2)/(M_2/R_2^2)$ of the gravitational forces of a planet (body 1) and the Sun (body 2) to be a measure of which body is the dominant one in the motion of the satellite. Indeed, he expresses surprise that the Moon is stable, since the ratio for that body is 0.46, much less than the value of 30 typical for the other satellites in the solar system.

There is, in fact, no problem with the stability of our own Moon, and Asimov's explanation of Mercury's lack of a satellite cannot be upheld. The reason is that the gravitational acceleration of the Sun on the Moon is very nearly equal at all times to that of the Sun on the Earth. The acceleration of the Moon *relative* to the Earth due to the Sun is therefore a tidal acceleration proportional to M_2R_1/R_2^3. Comparing this with the direct acceleration of the Earth on the Moon, we arrive at the ratio $(M_1/R_1^2)/(M_2R_1/R_2^3) = (M_1/R_1^3)/(M_2/R_2^3)$, which determines which body is dominant. (The near cancellation of the direct accelerations of the Sun is seen very clearly when the full equations of motion are written out, for which consult a standard text such as Brouwer and Clemence.[1])

For the Moon, this ratio is nearly 200, so that the Moon is well within the stable region. Nevertheless, the fact that the Sun's gravitational acceleration on the Moon is so nearly equal to that on the Earth means that the orbits of the two bodies around the Sun are very similar—so similar, in fact, that *the Moon's orbit is always concave towards the Sun,* a fact that is surprising to many at first and certainly in conflict with many illustrations in elementary texts. There are, in particular, no "loops" in the Moon's orbit around the Sun.

For Mercury, the point where the above ratio is unity occurs at a distance of over 3×10^5 km from Mercury, while Mercury's Roche limit is at roughly 6×10^3 km. It is clear that there is a large region where a satellite of Mercury could have a stable orbit.

Reference

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. . . A qualitative measure of the importance of the solar disturbing force on a Mercurian satellite is the size of the sphere of influence or, equally appropriate, the size of the Hill sphere. These imaginary spheres are regions where a particle can be considered to be under the control of Mercury and perturbed by the Sun; outside the spheres the particle is thought to be controlled by the Sun and perturbed by Mercury. A simple calculation shows these spheres to be 60 to 100 Mercurian radii in size. Satellites of Mercury thus have the vast range between the Roche limit and the outer boundary in which they can reside safely without suffering the fates proposed by Asimov; if this were not true, NASA would not even consider a Mercury orbiter.