

A Pair of Planets at a Pulsar's Periphery

In their very interesting and up-to-date article "The Search for Forming Planetary Systems" (April, page 22) Anneila I. Sargent and Steven V. W. Beckwith neglected to mention that the first extrasolar planetary system has already been discovered, by Aleksander Wolszczan and Dale A. Frail.¹ Two planets, each only a few times more massive than Earth, are orbiting a millisecond radio pulsar (a neutron star), PSR 1257+12, with orbital periods of about two and three months, respectively. This is certainly not a traditional environment in which planets were expected, but it strongly supports the notion that planets are easy to form, and it makes the case for the continued search only stronger. The planetary system found around PSR 1257+12 was discussed at many meetings, and it was the main topic of a conference at Caltech² in the spring of 1992. The precision of the pulsar timing data is very impressive: The amplitudes of the pulsar radial velocity change due to the two planets are approximately 43 cm/sec and 31 cm/sec, respectively, and these amplitudes are measured with an accuracy of a few millimeters per second. This high precision should make it possible to verify a theoretical prediction,³ namely that very small perturbations in the planetary motion are expected from the mutual gravitational perturbations of the two planets.

Careful studies of such Earth-like planets, including their mutual gravitational perturbations, are not accessible to any of the techniques described in Sargent and Beckwith's article, at least not in the foreseeable future.

References

1. A. Wolszczan, D. A. Frail, *Nature* **355**, 145 (1992).
2. J. A. Phillips, S. E. Thorsett, S. R. Kulkarni, eds., *Planets Around Pulsars*, Astron. Soc. Pac. Conf. Ser. 36, Astron. Soc. Pac., San Francisco (1993).

3. F. A. Rasio, P. D. Nicholson, S. L. Shapiro, S. A. Teukolsky, *Nature* **355**, 325 (1992). R. Malhotra, D. Black, A. Eck, A. Jackson, *Nature* **335**, 583 (1992). R. Malhotra, *Astrophys. J.* **407**, 266 (1993).

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SARGENT REPLIES: Bohdan Paczyński is correct in pointing out that in our article Steven Beckwith and I neglected to mention recent detections of planet-like objects around pulsars. I was a member of the organizing committee for the Caltech meeting to which he refers and am very aware of progress in this field. However, in writing for an audience as wide as the readership of *PHYSICS TODAY*, one is often forced to streamline one's approach. As a result, we confined ourselves largely to the question of observing planetary systems in formation. Fully developed objects orbiting pulsars were technically outside the scope of our review. And, of course, our mind-set was perhaps biased toward forming planetary systems that might eventually support life as we know it. It was certainly not our intention to denigrate pulsar-planet work by omitting all reference to it. We are delighted that Paczyński has drawn attention to this fascinating and related topic and provided references for readers who may wish to pursue it.

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Surface Screening: No Superficial Matter

I read Marc A. Kastner's well-written *PHYSICS TODAY* article on artificial atoms (January 1993, page 24) with much interest. One reason is that Kastner had the unenviable task of describing, without mathematics, surface screening by electrons in metals, where quantum and classical concepts sometimes come into conflict and one must give priority to one or the other, as appropriate.

There were at least two possible pitfalls. The first was on page 27, in dealing with the Coulomb blockade energy for a small particle, where the choice of an inappropriate phrase could have suggested to the reader that the electron interacts with itself. Kastner carefully avoided this trap by ascribing this term to "the repulsive interaction between the bits of charge on the particle."

The second was on page 28, where, in describing the "all-metal atom," Kastner writes, "The high density of electrons also results in a short screening length for external electric fields, so electrons added to the atom reside on its surface." This statement would, of course, be correct on replacement of "electrons added" by "electric charge added." However, as it stands it is a correct statement *only* if the added electrons go into surface states (or, speaking quantum chemically, surface orbitals), which (I assume) Kastner did not intend.

The point is that in the absence of surface states, the added electrons go into bulk states, just like all the other conduction electrons.

That leaves an apparent conflict with the classical notion (certainly applicable to artificial atoms) that excess charge goes to the surface of a conductor. The resolution is that all the electronic states make slight adjustments outward, enabling the bulk to remain neutral and leaving the excess charge (due to the sea of conduction electrons) to reside on the surface.

I make this comment as an extrapolation from having studied the related problem of screening at a metal surface,¹ where the wavefunctions of all the conduction band electrons are self-consistently perturbed by the presence of an external electric field. Only well after the calculations were completed and the work was published did I recognize the conceptual implications that quantum mechanics (actually, wave mechanics) has for our physical picture of ordinary electrostatic screening.

Children see illustrations of electricity with minus signs on conducting surfaces, which they are taught