tions, and the rotation of the major axis is not obtained".

To set the record straight: (i) The solution referred to is quite correct, as a simple check against the differential equation would show. It so happens that a term in an intermediate step was inadvertently omitted—a mere typographical error. (ii) Concerning the rotation of the major axis, suffice it to say that this had been obtained and the result published[4] almost a year prior to publication of King-Hele's paper, which I now understand was written in 1957. (iii) I am glad to state that the extension of the method to include the higher-order terms proceeds in a direct and straightforward manner. Moreover, the procedure yields detailed information not only regarding the secular motions of the node and perigee but also for the periodic terms, including orbit inclination, major axis and eccentricity.

Due to space limitations only the following expression for the regression of the nodes (those points on the celestial sphere where the satellite crosses the equator) is presented at this time, because of its relevance to determination of the oblateness parameters from satellite observations.

$$\Delta\varphi = \frac{2\pi JR^2\cos i}{a^2(1-e^2)^2}\left\{1 - \frac{JR^2}{24a^2(1-e^2)^2}\left[4(3-20\sin^2 i) - e^2(4+5\sin^2 i)\right] - \frac{JR^2}{12a^2(1-e^2)^2}\left[16(2-5\sin^2 i)e\cos\omega - (7-15\sin^2 i)e^2\cos 2\omega\right]\right\} + \frac{3\pi DR^4\cos i}{7a^4(1-e^2)^4}\left[(1+\frac{3}{2}e^2)(4-7\sin^2 i) - (3-7\sin^2 i)e^2\cos 2\omega\right]$$

Here $\Delta\varphi$ is the difference in right ascension between two successive ascending nodes, J and D are the coefficients of the second- and fourth-order harmonics in the potential function for the oblate Earth[5], R is the equatorial radius of the Earth, i is the inclination of the orbit to the equator, a and e are the semi-major axis and eccentricity of the osculating ellipse corresponding to the satellite at the node, and ω is the argument of perigee (angular distance from the node to perigee).

Note that: (1) The above expression is valid for arbitrary orbit inclination and eccentricity. (2) The linear term in J contributes only to the secular motion of the node. (3) The quadratic J^2-term contributes a constant (secular) plus two periodic terms; one periodic term has the period of precession of perigee, the other is a smaller term with half the period of perigee motion. (4) The D-term also contributes a constant (secular) term plus a periodic term having half the period of perigee motion. (5) The secular contribution of the D-term is a regression of the nodes for orbit inclinations less than 49·1° ($\sin^2 i = 4/7$); while for $i > 49{\cdot}1°$, the nodes advance. However, this motion is overshadowed by the dominant J-term.

It is of interest to calculate the magnitudes of the secular and periodic terms for satellite 1958β2 (*Vanguard* I). On the basis of the following data[6,7]: $(a/R) = 1{\cdot}3603$; $i = 34{\cdot}26°$; $e = 0{\cdot}1896$; $J = 1{\cdot}6232 \times 10^{-3}$; $D = 0{\cdot}885 = 10^{-5}$; we find the separate contributions of the J and D terms to be:

$$\Delta\varphi \text{ (deg./rev.)} = (0{\cdot}281 - 2{\cdot}79\times10^{-6}\cos\omega + 1{\cdot}79\times10^{-6}\cos 2\omega)_J + (3{\cdot}58\times10^{-4} - 5{\cdot}37\times10^{-6}\cos 2\omega)_D.$$

The dominance of the linear (secular) term in J is quite evident.

LEON BLITZER

Department of Physics,
University of Arizona,
Tucson, Arizona.

[1] King-Hele, D. G., *Proc. Roy. Soc.*, A, **247**, 49 (1958).
[2] Blitzer, L., Weisfeld, M., and Wheelon, A. D., *J. App. Phys.*, **27**, 1141 (1956).
[3] Blitzer, L., and Wheelon, A. D., *J. App. Phys.*, **28**, 279 (1957).
[4] Blitzer, L., *J. App. Phys.*, **28** 1362 (1957).
[5] Jeffreys, H., "The Earth", fourth edit., chapter 4 (Camb. Univ. Press, 1959).
[6] Orbital data as issued by *NASA* on Jan. 20, 1960.
[7] Values of J and D from Lecar, Sorenson and Eckels, *J. Geophys. Res.*, **64**, 209 (1959).

PROF. BLITZER has, I fear, misinterpreted my comments on his papers. First, I am glad to know that his solution for radial distance was correct. When I found the error in the intermediate equation, it did not seem worth carrying on with checking the analysis, which was extremely lengthy. I made it clear that my doubts about the correctness of the solution were based solely on the error in the intermediate equation. I then went on to say, "the solution is so lengthy that no progress can be made towards higher-order solutions, and the rotation of the major axis is not obtained". Here I was not making a prophecy but only a statement of fact: in the papers I was referring to, there was no progress towards a higher-order solution, and the rotation of the major axis was not obtained. My statement was therefore correct. Next, as is clearly stated on its second page, my paper was "a shortened version of a Ministry of Supply report issued in October 1957", and was written in the summer of 1957. It is therefore scarcely surprising that I made no reference to the paper (his ref. 4) by Prof. Blitzer, which was not published until November 1957.

Finally, Prof. Blitzer may be glad to know that I believe his equation for $\Delta\varphi$ is correct, if osculating elements are used, since it agrees with results obtained by other authors.

D. G. KING-HELE

Royal Aircraft Establishment,
Farnborough, Hants.

PHYSICS

Reduced Temperatures for Nucleation in Supercooled Liquids

THE various methods available for detecting a phase change may depend on spontaneous nucleation-rates which differ greatly in magnitude. Thus although, as nucleation theory shows, critical conditions for the threshold of change may be much the same for methods of widely different sensitivity they are nevertheless quite arbitrary. It therefore seems particularly interesting that critical supercoolings θ for droplets of molten metals and molecular liquids are roughly proportional to the absolute melting temperatures T_f (refs. 1, 2, and 3). Thus where $T_s = T_f - \theta$ is the freezing threshold these results indicate a value of about 0·8 for the reduced tempera-

©1960 Nature Publishing Group