Planetary harmony

David W. Hughes

The Harmony of the World: A Realization for the Ear of Johannes Kepler's Astronomical Data from Harmonices Mundi, 1619. Gramophone record. By John Rodgers and Willie Ruff. (Sky Publishing: Cambridge, Massachusetts, 1979.) \$11.50 (including postage and packing).

KEPLER, apart from being one of the greatest, is also one of the more endearing astronomers because of his habit of including in his books a detailed account of the blind alleys he went along as well as the paths of success. He was convinced that the ways in which knowledge is acquired are as important as the knowledge itself. It's a pity more people don't think the same today.

One of Kepler's main goals in life was the

discovery of the mathematical rules underlying the progression of planetary orbital sizes, shapes and periodicities. A blind alley on the journey to this goal was the hypothesis of planetary harmony — the mathematical music of the spheres. To quote from Kepler's book *Harmonices Mundi*: "The heavenly motions are nothing but a continuous song for several voices, to be perceived by the intellect, not by the ear; a music which, through discordant tensions, through syncopations and cadenzas as it were, progresses toward certain predesigned six-voiced cadences, and thereby sets landmarks in the immeasurable flow of time".

Each planet produces a tone proportional to its angular velocity as seen from the Sun and a tonal range which depends on the orbital eccentricity. The frequency of the note is a function of the heliocentric distances. Figure 1 shows the notes that Kepler thought the planets played.

Now Kepler might have been content to perceive the heavenly chords 'by the intellect' but I have always wanted to hear

them in reality and to listen to how they change as the planets orbit the Sun. Thanks to Professor Ruff of the School of Music, Yale, and Professor Rodgers of the Geology Department of the same university, this is now possible. The first 'fixed point' of their realisation is the mean frequency of the Earth, which they set at 800 Hz — very close to the *g* (a musical expression for the *g* note about an octave and a half above middle *c*) shown in Figure 1. The second fixed point is the orbital period of Pluto (248yr) which they musically set to be 20 min 42 s. Ruff and Rodgers have updated Kepler by introducing Uranus, Neptune and Pluto. As these planets have such low frequencies they have been simulated by a series of rhythmic beats — Uranus around 10 to the second, and so on. The long playing record covers the harmony of the spheres between 27 December 1571 (Kepler's birthday) and 1835. The record also includes introductions to the planetary sounds one by one. This sequence would have been much more useful if there had been a voice announcement introducing each planet.

Scientifically the record has considerable curiosity value, and the inclusion of copious sleeve notes and a copy of an explanatory paper by Rodgers and Ruff (*American Scientist*, 67, 286-292; 1979) makes it all the more useful.

Musically the sounds have been computer generated using an IBM 360/91, and I am in deeper water. My scant musical knowledge comes from struggling through to Grade 8 piano and my musical appreciation falls into the "I know what I like" category. Bearing these facts in mind I conclude that this record put on near the end of a party would be guaranteed to clear the room in minutes flat. □

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Figure 1 The 'notes' played by the planets.

Statistics in particle physics

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Probability and Statistics in Particle Physics. By A.G. Frodesen, O. Skjeggstad and H. Tofte. Pp.501. (Universitetsforlaget: Bergen, Oslo and Tromsø; Columbia University Press: New York, and Guildford, UK, 1979.) Nkr.150; \$30.

WHEN I saw the name of Skjeggstad among the authors of this book, I immediately recalled a set of lectures given by him on phase space at a CERN post-graduate school in 1964. These lectures were published as a CERN yellow report and have been part of the staple diet of research students ever since. I can see this book being used in much the same way, but

not only by research students.

This book is no 'fly-by-night' progress report. It contains much solid, and at times, difficult material presented in a readable way. Although it is aimed at particle physicists the clarity of presentation should give it wider appeal. The many examples are excellent and treat real situations in particle physics. There was for me one notable omission, however, namely the treatment of the significance of a bump ('Breit-Wigner') on a background. If the bump is big and narrow and the background flat then there is no problem. If the bump is not so big and coincides with the peak in the background and one is not completely sure about the shape of the background, then the procedure becomes tricky to put it mildly.

One further thing I would like to have seen. A general warning (almost like on cigarette packages) about using common-sense, as the treatment of errors can drive

one mad. I have too often seen computer output from students containing measured quantities with nonsensical errors or χ^2 , not because the error treatment was wrong but because it had not been applied in a sensible way. One finds hints of this in the book — on page 289, for example, in discussing "pulls" the reader is advised to throw out a nonsense point from the data if he gets a bad value for χ . However, I would like to have seen a more general warning given, possibly in the preface. In reading the preface I noted that the authors paid tribute to Kendall and Stuart for their *The Advanced Theory of Statistics* (Charles Griffin: London, 1963) in three volumes, which they constantly consulted. It was also my staple stand-by 30 years ago; then it was in two volumes and had one author. I wish the present authors good fortune. □

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