The redshifts of minimum angular diameter, Z_m, have been calculated as a function of q_0 and α in the zero-shear IFM (Fig. 1). The determination of Z_m is, in itself, not sufficient to determine q_0. Thus, for example, if $Z_m = 1.6$, then $0.25 \leq q_0 \leq 2.0$ corresponds to $1 \geq \alpha \geq 0.3$; and to determine q_0 requires that α be specified. Note that if $\alpha = 0$ there will be no minimum angular diameter regardless of the value of q_0.

The interpretation of further observations of the angular diameter-redshift relation may provide a simple test for the existence of an intergalactic medium, if the acceleration factor can be estimated independently.

This work has been supported by the National Research Council of Canada.

R. C. Roeder

Scarborough College and David Dunlap Observatory, University of Toronto, West Hill, Ontario, Canada

Received February 13; accepted April 1, 1975.

1 Hewish, A., Readhead, A. C. S., and Duffett-Smith, P. J., *Nature*, **252**, 657 (1974).
2 Dyer, C. C., and Roeder, R. C., *Astrophys. J. Lett.*, **174**, L115 (1972); **180**, L31 (1973); *Astrophys. J.*, **189**, 167 (1974).
3 Schücking, E. L., *Z. Phys.*, **137**, 595 (1954).
4 Kantowski, R., *Astrophys. J.*, **155**, 89 (1969).

Harmonic analysis of the light of DQ Herculis

Several classes of interacting binary stars, such as the dwarf novae, nova-like variable stars and X-ray stars, present many examples of rapid periodic optical variations. DQ Herculis (nova 1934) is, however, the only nova known to show such variations. They are of low amplitude, generally less than 0.04 mag semi-amplitude, and have a period of 71.065459 s (refs 1–3). We report here a study of the harmonic components of the 71-s periodicity, and show that the results place severe limits on the available models of the variation.

The observations were made in June, August and September, 1973 at the Cassegrain focus of the 2.08-m telescope of the McDonald Observatory using the high speed two-channel photometer developed by Nather and Warner[4]. The data consist of six observing runs totalling 14.4 h of photometry of DQ Herculis; data taken during eclipse were not included. Individual power spectra were computed for each of the observations and these spectra were then averaged together to produce the power spectrum shown in Fig. 1. The frequencies corresponding to the 142-s subharmonic and to the higher harmonics of the 71-s variation are indicated.

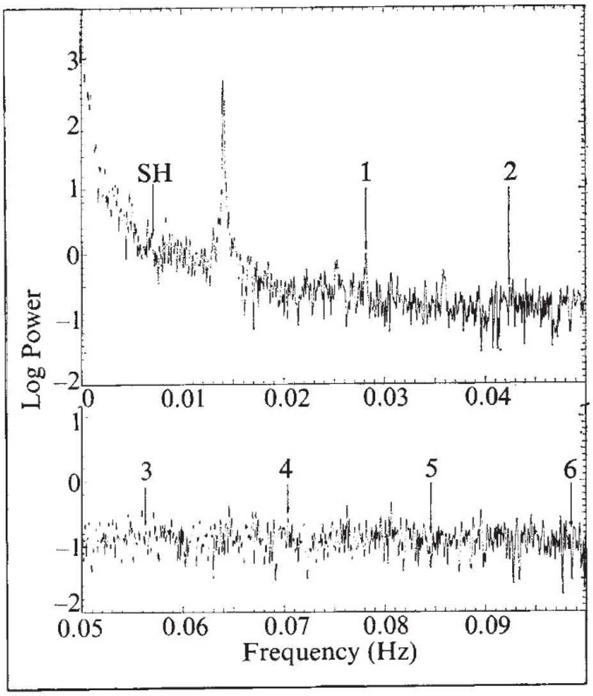

Fig. 1 Log of averaged power of the light of DQ Her showing the harmonic character of the 71-s periodicity. Frequencies corresponding to the 142-s subharmonic (SH) and to the higher harmonics (numbered) are indicated by arrows.

The prominent peak corresponds to the 71-s periodicity and is nearly three orders of magnitude above the noise. At the subharmonic frequency, the contribution to the power spectrum is consistent with the surrounding noise level, which is dominated by the optical flickering of DQ Her. The power at the subharmonic frequency is less than the power at the fundamental frequency by a factor of 310 (17.6 in amplitude).

There are no highly significant harmonic components to the 71-s variation. There is, however, evidence for the existence of the first harmonic, since the highest point of the 1,680 points in the power spectrum that lie at frequencies higher than 0.016 Hz is found precisely at the frequency of the first harmonic. After subtraction of noise, it is found that the contribution of this component is less than that of the fundamental by a factor of 600 in power (24 in amplitude). These values correspond to a maximum semi-amplitude for the first harmonic of 0.0017 mag. The remainder of the observed power spectrum has a shape and level consistent with white noise. A conservative upper limit to periodic components in the frequency range of 0.028–0.1 Hz is 0.0014 mag.

Two major groups of models have been advanced to explain the 71-s variation of DQ Her: non-radial white dwarf pulsations and a rotating white dwarf with a dipole magnetic field[3,5–8]. In general, a rotating white dwarf with a dipole magnetic field should produce a 142-s subharmonic because of physical and geometric asymmetries between the two poles. On the other hand, pulsational models could also require significant contributions to the power at the harmonic frequencies. Our study has shown that the 71-s variation of DQ Her is a sinusoid of remarkable purity, with a small harmonic contribution to the power occurring only at the frequency of the first harmonic. Consequently, no model of the variation can be considered complete unless it is consistent with this purity.

We thank Mr John McGraw for assistance and discussion, and Dr E. L. Robinson for comments and suggestions.

Alan L. Kiplinger

Department of Astronomy, University of Texas, Austin, Texas 78712

R. E. Nather

Department of Physics and Astronomy, Tel Aviv University, Ramat Aviv, Israel

Received February 24; accepted April 1, 1975.

1 Walker, M. F., *Astrophys. J.*, **123**, 68–89 (1956).
2 Nather, R. E., and Warner, B., *Mon. Not. R. astr. Soc.*, **143**, 145–165 (1969).
3 Warner, B., Peters, W. L., Hubbard, W. B., and Nather, R. E., *Mon. Not. R. astr. Soc.*, **159**, 321–335 (1972).
4 Nather, R. E., and Warner, B., *Mon. Not. R. astr. Soc.*, **152**, 209–217 (1971).
5 Bath, G. T., Evans, W. D., and Pringle, J. E., *Mon. Not. R. astr. Soc.*, **166**, 113–121 (1974).
6 Lamb, D. Q., *Astrophys. J. Lett.*, **192**, L129–L133 (1974).
7 Kemp, J. C., Swedlund, J. B., and Wolstencroft, R. D., *Astrophys. J. Lett.*, **193**, L15–L19 (1974).
8 Herbst, W., Hesser, J. E., and Ostriker, J. P., *Astrophys. J.*, **193**, 679–686 (1974).