No Boundaries

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Reference No.: TRPR1/01

Dear Don

Report: Revue of Proposal for Research and Development in the Area of High-Energy Sonoluminescence

Please find enclosed the above report as requested in your letter dated September 26, 1997.

I wish you much success with any future developments in this most interesting of projects. Good luck!

If I could be of any further assistance, do not hesitate to contact me.

Yours sincerely

Raffaele Cammarano

15 October 1997

encl.

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Report:

Revue of Proposal for Research and Development in the Area of High-Energy Sonoluminescence

(Reference No.: TRPR1/01)

15 October 1997

REVUE OF RESEARCH PROPOSAL

Introduction

I have been requested (communication, Sept 26 1997) to revue the "Proposal for Research and Development in the Area of High-Energy Sonoluminescence" with respect to its worth as a research and development project.

The objective of the proposed project is to scale up the size of imploding shock waves, previously generated on a much smaller scale in direct sonoluminescence (SL), by means of a novel resonant liquid piston produced by large centrifugal acceleration in a rapidly rotating mechanical system.

On the basis of the information supplied to me by Mr Don Cooper, it is my belief that the proposal has scientific and technical merit and should be considered with an additional, more comprehensive, feasibility study. It should be noted at the outset that the following more detailed comments and opinions expressed here are solely my own, based on the limited information provided to me as mentioned above.

Additional Comments

It seems evident that the author is aware of the major limitations of the proposed design as discussed in Section 3.3. Some additional considerations are outlined below.

1) The conventional generation of the SL state from small bubbles (typically around 1 to 10μm diameter) requires (ideally) a perfectly spherical bubble which is introduced into the driving sound field. The level of energy concentration (that is, the maximum temperatures and pressures attainable) which can be attained is limited by the stability of an imploding spherical shock wave. This is the currently accepted (incomplete) theory. The proposed system will produce an alternating hydrostatic pressure by means of centrifugal acceleration. Thus, at a given cross-section which is not parallel to the axis of rotation, the hydrostatic pressure profile will not be symmetric, but will be dependent on the radius of rotation. How this will affect bubble formation and the transition to SL is unclear. In fact the temperatures achieved are dependent on how close the shock front gets to the centre of the bubble [1]. The closer the inward moving shock front approaches the centre of the bubble, the higher the maximum temperature. Therefore, any asphericity and other introduced instabilities (eg. coupling with mechanical vibrations) may limit the extent of the implosion and hence the maximum temperature achievable. Collaboration with noise and vibration control experts at the Department of Mechanical and Materials Engineering, University of Western Australia (namely, Professors Brian Stone and Michael Norton) would be invaluable.

2) Also of concern is that currently no theory can explain how particular sized bubbles form. Given the highly nonlinear nature of the SL system as clearly indicated by the experimentally measured dynamic response of the maximum bubble radius to sudden changes in drive level (dynamic acoustic pressure amplitude) [2], the problems of scaling up (by three orders of magnitude in linear dimension in this proposal) should be more thoroughly investigated. Collaboration with a theoretical physicist experienced in similar areas may be useful.

3) As with many nonlinear systems, experiment precedes theory. In this respect, experience gained from the proposed system would be invaluable for a more complete theoretical understanding of SL, which in turn may lead to specifications for commercially oriented systems.

4) At this stage of development, given the current level of knowledge of SL and the difficulty of anticipating all interactions and phenomena which may be important at larger scales, it is my belief that the proposed system should be considered an experimental project with the possibility of commercialisation at least 10 to 15 years away. Nanophase and amorphous materials production and the destruction of toxic chemicals seem to be the most viable conceivable commercial application at this stage. The former application is indeed considered as strategic by many nations.

In view of the extreme sensitivity of SL to small changes in controllable experimental parameters, there is sure to be some unexpected surprises in the proposed system.

5) The proposal provides no information regarding how the new system will be characterised and assessed. Further work is required here.

Conclusion

As with any innovative research exploring (relatively) newly discovered phenomena, the likely "success" of the proposal is difficult to assess, however, the potential discoveries (and there will certainly be many, given the highly nonlinear nature of the SL system) and spin-offs will invariably be scientifically and commercially significant. A pilot-study of this nature should run for a minimum of about 15 person-years (eg, 5 people for 3 years) to more fully assess the potential of the technology.

It is important that expertise in likely problem areas is to be found locally.

[1] Putterman S. J., *Sonoluminescence: Sound into Light,* Scientific American, pp32-37, February, 1995.

[2] Barber B. P., C. C. Wu, R. Lofstedt, P.H. Roberts, and S.J. Putterman, *Sensitivity of Sonoluminescence to Experimental Parameters,* Phys. Rev. Lett., 72, 9, pp1380-1383, 1994.