



ELSEVIER

Physica A 304 (2002) 461–479

PHYSICA A

www.elsevier.com/locate/physa

# Quantum mechanical model of a plasma system: a challenge to the second law of thermodynamics

V. Čápek<sup>a,\*</sup>, D.P. Sheehan<sup>b</sup>

<sup>a</sup>*Faculty of Mathematics and Physics, Institute of Physics, Charles University, Ke Karlovu 5,  
121 16 Prague 2, Czech Republic*

<sup>b</sup>*Department of Physics, University of San Diego, San Diego, CA 92110, USA*

Received 14 April 2001; received in revised form 24 September 2001

---

## Abstract

Within the framework of the theory of open quantum systems, a rigorous model is developed and applied to a previously proposed and experimentally corroborated plasma system that challenges the second law of thermodynamics (Sheehan, *Phys. Plasmas* 2 (1995) 1893; *J. Scient. Explor.* 12 (1998) 303). The results of the present model support the findings of the earlier challenge. © 2002 Elsevier Science B.V. All rights reserved.

*PACS:* 05.30.-d; 05.70.-a; 44.90.+c

*Keywords:* 2nd law challenge

---

## 1. Introduction

Challenges to the second law of thermodynamics [1,2] are almost as old as the law itself, dating back at least to the 1870s with Maxwell's celebrated demon [3–6]. Since then new challenges have been proposed by successive generations of physicists, each examining new facets of the law, and extending its limits of applicability. Although most challenges have been resolved under close scrutiny [5,7,8], some have persisted. Through their resolutions, those that have been resolved have deepened our understanding, while those that have not spur us toward deeper insights.

It is important to note that no general proof of the second law has been discovered either in the classical or quantum mechanical regime. (Proofs are claimed for idealized classical macroscopic systems [9]; proofs for quantum mechanical systems are

---

\* Corresponding author. Tel.: +42-2-2191-1330; fax: +42-2-2492-2797.

*E-mail address:* capek@karlov.mff.cuni.cz (V. Čápek).