THERMAL HISTORIES OF CHONDRULES IN SOLAR NEBULA SHOCKS. M.A. Morris[1], S.J. Desch[1], and F.J. Ciesla[2]. [1]School of Earth and Space Exploration, Arizona State University. Email: melissa.a.morris@asu.edu. [2]Department of the Geophysical Sciences, University of Chicago.

Introduction: Chondrule formation is a long-standing problem in meteoritics. Furnace experiments designed to reproduce chondrule textures constrain their cooling rates between their liquidus and solidus temperatures to be in the range 10-1000 K/hr [1]. This constraint is satisfied if chondrules were melted by passage through solar nebula shocks, as are nearly all other known constraints on chondrule formation [2-4, 8]. Models show that after passing through the shock, chondrules are heated by thermal exchange with the shocked gas, by absorption of radiation from dust and other chondrules, and by supersonic drag heating. As such, accurate calculation of the gas temperature is crucial, in order to determine chondrule temperatures. While the nebular shock model successfully explains many aspects of chondrule formation, there remain differences between the models [2-4, 8] that predict moderately different physical conditions at the site of chondrule formation, as reviewed by [5]. These differences all involve the calculation of the effects of radiation, especially the radiative losses from molecular line emission, the opacity of solids, and the input radiation field. Here, we present the first complete calculations of chondrule thermal histories that include all of the corrections to the chondrule shock model deemed necessary by [5]: dust opacity, appropriate radiation field boundary conditions, and line cooling from moderate optical depths of water molecules. We use updated rates of line cooling as calculated by [6-7].

Discussion: Among the effects caused by emission of radiation by water molecules is an overall decrease in temperatures. Slightly higher shock speeds of 9 km/s are needed for consistency with chondrule melting (as compared to previous estimates of 7 km/s [2-4]). Cooling rates of chondrules through their crystallization range (approximately 1400-1800 K) are not significantly altered, compared to the case without line cooling, and the shock model remains consistent with known constraints on chondrule melting. These results, and others, will be presented at the conference.

References: [1] Hewins, RH, Connolly HC Jr., Lofgren, GE, & Libourel, G 2005. in Chondrites and the Protoplanetary Disk, ASP Conference Series 341, p. 286. [2] Iida, A, Nakamoto, T, Susa, H & Nakagawa, Y 2001. Icarus 153, 430. [3] Desch, SJ & Connolly H C 2002. Meteoritics & Planetary Science 37, 183-207. [4] Ciesla, FJ & Hood LL 2002. Icarus 158, 281. [5] Desch, SJ, Ciesla, FJ, Hood, LL & Nakamoto, T 2005, in Chondrites and the Protoplanetary Disk, ASP Conf Series 341, p. 849. [6] Morris, MA, Desch, SJ, & Ciesla, FJ 2007. M&PSA 42, 5214. [7] Morris, MA, Desch, SJ, & Ciesla, FJ, 2009, ApJ 691, 320. [8] Miura, H & Nakamoto, T 2006 ApJ 651, 1272.