TEMPERATURE DEPENDENT THERMAL EXPANSION OF ASTEROIDS. L. Pohl and D. T. Britt, University of Central Florida Department of Physics, 4111 Libra Dr, Orlando FL 32816, pohl@knights.ucf.edu; Center of Lunar and Asteroid Surface Science, 12354 Research Pkwy Suite 214, Orlando FL 32826.

Introduction: Every material changes the volume it occupies with temperature. This is characterized by its volumetric thermal expansion coefficient $\alpha_V(T) = \frac{1}{V}\left(\frac{dV}{dT}\right)_p$ which is temperature dependent. The temperature depth profiles of asteroids orbiting the Sun are similar to that of a damped oscillator. The material inside the asteroid undergoes expansion and contraction at different rates as a function temporal and spatial variation of the temperature profile. In general, we expect the asteroid to expand in volume close to the Sun and shrink far away from the Sun. This effect can be expected to be more profound the larger the eccentricity of the orbit. Further, the asteroid elongates, or deforms, due to the diurnal rotation. Finally, the differential rates of expansion within the asteroid cause stresses. Again, the magnitude of these effects scales with both the coefficient of thermal expansion and the eccentricity of the orbit.

Method: In our work, we estimate the volume and shape changes of asteroids due to the temperature dependence of the thermal expansion coefficient on temperature. We use thermal profiles of asteroids at various points in their orbits and calculate the elongations in various directions while assuming the original shape to be that of a sphere. The thermal profiles are calculated from a 1D Heat Conduction Equation (HCE). From this simple 1D slab model, we also estimate the possible volume changes. We make use newly available experimental data by [1] on the temperature dependence of the linear thermal expansion coefficient for important meteorite groups. For this analysis, we assume that the asteroid is made up of 1D slabs and that the heat only conducts within each slab. Then for each such a 1D slab, we have a temperature profile $T(t,x)$ for each time instant. We can then simply calculate the elongation of a 1D slab by:

$$\Delta\mathrm{L} = \int_0^L \Delta L(x) = \int_0^L L_{t_0}(x)\left[e^{\int_{T(t_0,x)}^{T(t,x)} \alpha(T)\,\mathrm{d}T} - 1\right],$$

Where $\Delta L(x)$ is the elongation of a slab's element at depth x, $L_{t_0}(x)$ is the original length of the slab's element located at depth x at time instant t_0, $T(t_0,x)$ and $T(t,x)$ are the respective temperatures at the depth x of the given slab in the two time instants. If we calculate this for enough slabs that represent the shape of an asteroid, we can then estimate the shape change of the asteroid as a function of time or position on the orbit.

Discussion: The effect of volume change will be most apparent for asteroids on highly eccentric orbits. Unfortunately, the current data is only available for temperatures from 5 - 300 K which precludes application of these calculations to the full orbit of NEAs and the current use is limited to main belt asteroids and the behavior of NEAs in the outer portions of their orbits. Also the current dataset includes only a limited amount of meteoric materials. Yet, general shape change is mostly due to the diurnal variations. The most important information coming from our results is whether the effect of volume or shape change, due to the thermal dependence of expansion coefficient, is significant or negligible. Based on the general fact that for most asteroidal materials, the heat wave penetrates only a very thin subsurface layers, we can expect that the shape change will be negligible (as the temperature varies in a very shallow layer under the surface) and therefore asteroids on mostly circular orbits will be unaffected. On the other hand, we can probably observe some volume changes for asteroids on highly eccentric orbits.

Conclusions: We determine the significance of thermal dependency of linear expansion coefficient of some asteroidal materials for changes in volume and shape during an asteroid's orbit.

We also examine the significance of this effect for the induced thermal stresses inside the asteroid as opposed to the situation with temperature independent expansion coefficient.

References: [1] Opeil, C. and Britt, D. (August 2016) *Thermal Expansion, Heat Capacity and Thermal Conductivity Measurements of CM Carbonaceous Chondrites*. Abstract: PS11-A018.