# NUMERICAL HYDRODYNAMIC SIMULATIONS OF SPICULES

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## 1. Introduction

Solar spicules have intimate relations to the bright points in the network. (Stenflo, 1976). We suppose that the bright points at the footpoints of the spicule correspond to the bright elements of the photospheric network or faculae. According to Mehltretter (1974), the facular points appear and disappear within only 2-3 min. Therefore we investigate how the sudden heating at the photospheric level in a magnetic flux tube generates the spicule.

## 2. Method of Numerical Simulations

The idea and method of our simulations are similar to Steinolfson et al.'s (1979) who recently performed one dimensional hydrodynamic simulations of surges. We consider an initially static atmosphere in a vertically oriented magnetic tube. The static atmosphere has the temperature distribution given by HSRA model (Gingerich et al.,1971) and A model of Gabriel (1976). The pressure is enhanced abruptly by the heating at a base height (denoted by $h_0$) of this model atmosphere and the pressure enhancement (denoted by $p/p_0$) is kept for 5 min. The succeeding behavior of the atmosphere is pursued by solving hydrodynamic equations numerically by using the Modified Lax-Wendroff method with a artificial viscosity. The adiabatic motion and the constant cross section of the tube are assumed. From some empirical facular models we estimate $h_0$ in the range of 100-550 km and $p/p_0$ in the range of 1.1-2.2. The origin of the height is at the level of $\tau_{5000} = 1$ in HSRA model.

## 3. Results

The results of the simulations with parameters treated here are not qualitatively different each other. In Figure 1(a)-(b) we present the result which is gained when $h_0$ = 360 km and $p/p_0$ = 1.5. As seen in Figure 1(a), the pressure enhancement at the base generates a shock wave which gets strong as it passes upward through the chromosphere. Then the shock collides with the chromosphere-corona interface. As the result, the interface begins to move upward with average rising velocity of 30 km $s^{-1}$ and reaches the maximum height of about 7000 km. The upward motion of the interface can be easily understood if one regard it as a kind of contact discontinuity. Hence we can regard the cool and dense (see Figure 1(b) ) chromospheric matter behind the moving interface as the solar spicule The spicule in our model shows nearly ballistic motion and recurrent behavior. The latter property is due to the shock generated by wake through a non-linear effect. The parameters $(h_0, p/p_0)$ = (0, 1.1),(180, 1.2), (540, 1.7) can yield the spicule whose height is 6000 km, while (180, 1.5) and (540, 3) yield


Fig. 1 (a)

the spicule with the height of 12000 km. These parameters do not conflict seriously with empirical facular models if the adiabatic pressure change corresponding to the maximum temperature excess of the facula is assumed.

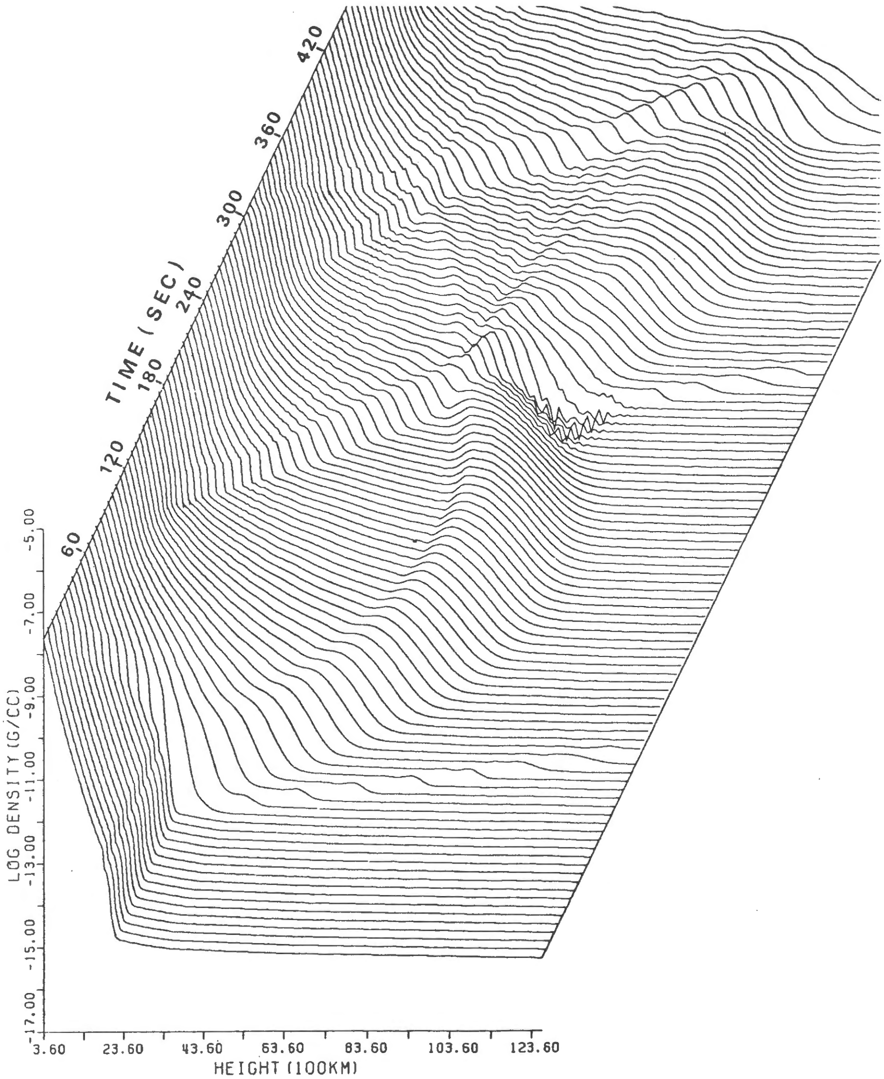


Fig. 1 (b)

Fig 1(a) The time variation of the temperature distribution in the case of $h_0$ = 360 km and $p/p_0$ = 1.5. Each curve represent the profile of the temperature at every 6 sec. (b) The time variation of the density distribution.

References


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