Qualitative dynamics of a simple system with unilateral contact and Coulomb friction

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From a physical or an experimental point of view this study is largely motivated for example by the occurence of vibrations in any sliding system or by the need to control mechanisms submitted to dry friction. In order to be able to carry out analytical computations we restrain our study to the well known simple model given by Klarbing which is here submitted to an oscillating excitation. This system has essentially been studied with a quasi static approach. We have adopted a dynamical analysis and in recent works have studied the trajectories in order to give stability properties on the equilibrium states [2],[3] and investigated specific sliding situations [1].
In the present work we show that below a critical value of the amplitude of the excitation there exist only equilibrium solutions and all trajectories attain these equilibria in finite time. Strictly above this critical value there no longer exist any equilibrium states but different kinds of periodic solutions appear. When the amplitude of the excitation is equal to the critical value, equilibrium solutions and periodic ones may coexist.
The part of the period-amplitude plane of the excitation where no equilibrium solution exists is by far the most interesting one and shall occupy the main part of the talk.

- It is easy to establish that when the period of the excitation is sufficiently large there always exists a periodic solution in phase with the excitation together with infinitely many periodic solutions of double period.
- When the period of the excitation is small we show that there always exist periodic solutions of the same period as the excitation. Their amplitude increases with the period of the excitation. The main qualitative feature in this case is the occurence of a phase difference with the excitation.
- Between these two ranges we find and analyse an intricate zone in the period-amplitude plane where different shapes of periodic solutions exist. We identify in this zone a region, one may assimilate to a resonance region, where all the trajectories loose contact even for small amplitudes.

References

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