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The stagnation-point flow and heat transfer of nanofluid over a shrinking surface in magnetic field and thermal radiation with slip effects : a stability analysis

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Abstract. A numerical study is performed to evaluate the problem of stagnation – point flow and heat transfer towards a shrinking sheet with magnetic field and thermal radiation in nanofluid. The Buongiorno's nanofluid model is used in this study along with slip effect at boundary condition. By using non-similar transformation, the governing equations are able to be reduced into an ordinary differential equation. Then, the ordinary differential equation can be solved by using the bvp4c solver in Matlab. A linear stability analysis shows that only one solution is linearly stable otherwise is unstable. Based on the numerical results obtained, the dual solutions do exist at certain ranges in this study. Then, the stability analysis is carried out to determine which one is stable between both of the solutions.

1. Introduction

The literature has shown the dual solutions is exist especially in solving shrinking sheet problem. Miklavčič and Wang [1] were the first who claimed that the solutions are non-unique for the shrinking sheet. In that case, a stability analysis is important to check which one is stable between the two solutions. Traditionally, Merkin [2] have shown that the stable one is the first solution while the second solution is not, by solving mixed convection in a porous medium problem. Then, there has been renewed interest in stability analysis as reported by Weidman et al. [3].

Recently, a considerable literature has grown up around the theme of stability analysis. Several studies investigating stability analysis have been carried out by Postelnicu and Pop [4], Roşca and Pop [5] and Mahapatra and Nandy [6]. The aim of the current study was to resolve the stability of the existing dual solutions in the stagnation – point flow over a shrinking sheet in magnetic field and thermal radiation with included slip effects in nanofluid.

2. Problem Formulation

Let we consider a viscous, incompressible and electrically conductive fluid on steady two-dimensional stagnation-point flow toward a shrinking sheet. Magnetic field B_0 with is uniform is applied into the sheet. $u_w(x) = cx$ is assumed as the velocity of stretching/shrinking and $U(x) = ax$ is represent the free stream velocity. In addition, the value of a and c are constant. To be noted, $c > 0$

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