GRAVITATION: AN ELEMENTARY EXPLANATION OF THE PRINCIPAL PERTURBATIONS IN THE SOLAR SYSTEM

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PREFACE

TO THE FIRST EDITION.

In laying this work before the public, I think it right to state the object for which it was originally composed, and the circumstances which have in some degree changed its destination.

The treatise was originally designed for a class of readers who might be supposed to possess a moderate acquaintance with the phænomena and the terms of astronomy; geometrical notions sufficient to enable them to understand simple inferences from diagrams; two or three terms of algebra as applied to numbers; but none of that elevated science which has always been used in the investigation of these subjects, and without which scarcely an attempt has been made to explain them. I proposed to myself, therefore, this general design: to explain the perturbations of the solar system, as far as I was able, without introducing an algebraic symbol.

It will readily be believed that, after thus denying myself the use of the most powerful engine of mathematics, I did not expect to proceed very far. In my progress, however, I was surprised to find that a general

explanation, perfectly satisfactory, might be offered for almost every inequality recognised as sensible in works on Physical Astronomy. I now began to conceive it possible that the work, without in the smallest degree departing from the original plan, or giving up the original object, might also be found useful to a body of students, furnished with considerable mathematical powers, and in the habit of applying them to the explanation of difficult physical problems. With this idea, the treatise is now printed in a separate form.

The utility of a popular explanation of profound physical investigations is not, in my opinion, to be restricted to the instruction of readers who are unable to pursue them with the powers of modern analysis. Much is done when the interest of a good mathematician is excited by seeing, in a form that can be easily understood, results which are important for the comprehension of the system of the universe, and which can be made complete only by the application of a higher calculus. That such an interest has operated powerfully in our Universities, I have no doubt. How many of our students would have known anything of the Lunar Theory, if they had not been enjoined to read Newton's eleventh section? And how many at this time possess the least acquaintance with the curious and complicated, but beautiful, theory of Jupiter's satellites, of which no elementary explanation is laid before them? But this is not all. The exercise of the mind in understanding a series of propositions, where the last

conclusion is geometrically in close connexion with the first cause, is very different from that which it receives from putting in play the long train of machinery in a profound analytical process. The degrees of conviction in the two cases are very different. It is known to every one who has been engaged in the instruction of students at our Universities, that the results of the differential calculus are received by many, rather with the doubts of imperfect faith than with the confidence of rational conviction. Nor is this to be wondered at; a clear understanding of many difficult steps, a distinct perception that every connexion of these steps is correct, and a general comprehension of the relations of the whole series of steps, are necessary for complete confidence. An unusual combination of talents, attainments, and labour, must be required, to appreciate clearly the evidence for a result of deep analysis. I am not unwilling to avow that the simple considerations which have been forced upon me in the composition of this treatise, have, in several instances, contributed much to clear up my view of points, which before were obscure, and almost doubtful. To the greater number of students, therefore, I conceive a popular geometrical explanation is more useful than an algebraic investigation. But even to those who are able to pursue the investigations with a skilful use of the most powerful methods, I imagine that a popular explanation is not unserviceable. The insight which it gives into the relation of some mechanical causes and geometrical effects, may powerfully, yet imperceptibly,

influence their understanding of many others which occur in the prosecution of an algebraical process. The advanced student who exults in the progress which the modern calculus enables him to make in the Lunar or Planetary Theories, perhaps, hardly reflects how much of the power of understanding his conclusions has been derived from Newton's general explanations.

The utility of such a work being allowed, it cannot, I think, be disputed that there exists a necessity for a new one. The only attempts at popular explanation in general use with which I am acquainted, are Newton's eleventh section, and a small part of Sir John Herschel's admirable treatise on Astronomy. The former of these (the most valuable chapter that has ever been written on physical science), is in some parts very defective. Thus, the explanation of the motion of the line of apses is too general, and enters into particular cases too little, to allow of a numerical calculation being founded on it. The explanation of evection is extremely defective. The explanation of variation, however, and of alteration of the node and inclination, are probably as complete as can be given. The latter treatise, besides expanding some of Newton's reasoning, alludes to the long inequalities and secular disturbances of the planets, but not perhaps with sufficient accuracy of detail to supersede the necessity of further explanation. No popular work with which I am acquainted, alludes at all to the peculiarities of the theory of Jupiter's satellites.

I have attempted in some degree to supply these

defects; with what success the reader must judge. As it was my object to avoid repetition of theorems, which are to be found in treatises on Mechanics and elementary works on Physical Astronomy, and which are fully read and mastered by those who take much interest in these subjects, and which, moreover, do not admit of popular explanation so easily as many of the more advanced propositions, I have omitted noticing them any further than the consistency of system seemed to require. Thus, with regard to elliptic motion, Kepler's laws, &c., I have merely stated results; because the investigation of these are familiar to the higher students, to whom I hope the other explanations may be useful; and because without great trouble it did not appear possible to put the reasons for these results in the same form as those for other effects of force. I have, however, alluded to some of the difficulties which are apt to embarrass readers in the first instance, as much for the sake of the reasoning contained in the explanation as for the value of the results. The only additions which I have thought it desirable to make for the benefit of readers of Newton, are contained in a few notes referring to one of Newton's constructions.

To the reader who may detect faults in the composition of the work, I can merely state in apology, that it has been written in a hurried manner, in the intervals of very pressing employments. I have only to add, that, holding a responsible situation in my University, I have always thought it my duty to promote, as far as I am able, the study of Physical Astronomy; and that