THE 29TH OF MAY OR SIR ARTHUR AND THE BENDING LIGHT

MICHAEL KATZ

Faculty of Education, Haifa University, Mount Carmel, Haifa, Israel
E-mail: michaelk@edu.haifa.ac.il

Abstract - In this paper I present an instance illustrating a program of joint teaching of science and literature. The instance sketched here rests on recognition that at the age when children read books like Kästner's "The 35th of May" they can already taste notions of Relativity Theory through the story of Eddington's expedition to Principe Island. Eddington's story is briefly recounted here with references to Kästner's book. The relationships thus exhibited between science and fiction, fantasy and reality, theory and actuality, humor and earnestness, should help evoke school age children's interest in science and literature at early stages in their studies' endeavor.

Key Words - Bending Light, Fantasy, Gravitation, Relativity, Science and Literature

I. INTRODUCTION

The idea that teaching science and humanities in primary and secondary schools needn't necessarily be seen as disjoint objectives is prevalent in the thought and practice of more than a few scholars and teachers in recent years. Carole Cox [1], for example, unfolds forty strategies of literature based teaching of various topics in arts and sciences. The particular suggestion considered here is using Erich Kästner's book "The 35th of May, or Conrad's Ride to the South Seas" [2] in studying the story of Sir Arthur Eddington's expedition dispatched to Principe Island to test, under full solar eclipse, Albert Einstein's General Relativity Theory's notion of bending light. The material in the five pages below can be handled in classrooms of Grades 4 and up in primary schools. It can also be issued as a book or booklet, illustrated by a couple of pictures from Kästner's book, a couple of paragraphs from Eddington's book [3], recounting his journey and findings, and a couple of drawings depicting solar eclipses and paths of bending light, as can be found in, e.g., Mary Colson [4]. The title of the classroom's lessons, or of the book or booklet, can be "The 29th of May or Sir Arthur and the Bending Light", as here above, or "The 29th of May or Arthur's Ride to the Southern Continent". The second option is closer to the title of Kästner's book, but the first one might be more appetizing to the young student.

II. TWO JOURNEYS

The end of May, or a few days after, seems to be the time for journeys of fantasy.
On the 35th of May Conrad embarked upon his journey to a series of fantasy lands in the South Seas. Together with his uncle he was riding Negro Caballo, a black horse that could speak, knew all about German literature and was world champion in roller skating. Needless to say, along the way they enjoyed a line of amazing experiences.
This is the essence, in three sentences, of the plot of "The 35th of May, or Conrad's Ride to the South Seas" – a story of adventure and humor by Erich Kästner, the well known German author of more than a few dearly loved novels, mostly for children and adolescents. The book was first published in German in 1931 and in English shortly after. Twelve years earlier, in 1919, another journey culminated on the 29th of May – Sir Arthur Eddington's journey to Principe Island in the southern continent called Africa. This was a real journey to a real place, just as the date is a real date. Yet in some ways Eddington's journey southwards appeared to be no less of a fantasy than Conrad's journey southwards. And it shows that the distance between science and fiction is sometimes much shorter than most people tend to believe.

III. SOME NOTIONS OF RELATIVITY THEORY

It all started with Albert Einstein's theory of relativity. In the year 1905 Einstein published an article whose content came to be known as Special Relativity Theory. More than a few revolutionary ideas were contained in this article – among them the relativity of speed (except for the speed of light which is constant) and the notion of time dilation.
Time dilation, one might be tempted to argue, is a hilariously hidden factor in Erich Kästner's story, where Conrad and his uncle, riding Negro Caballo, leave from home in Berlin after lunch, travel to the Southern Seas through exotic lands and cities, through fields and forests, through regions of horror and pleasure, and finally get back home in time for dinner at 7pm.
Another striking idea, in another 1905 paper of Einstein, is the interchangeability of mass and energy. Here we find the first version of the famous formula whose known version is $E = mC^2$, asserting that when mass (m) turns into energy (E) the amount of energy released is the mass multiplied by the speed of light (C) squared.
All of this stood in stark contradiction with Isaac Newton's laws as summarized at the start of the eighteenth century in his celebrated Principia. For nearly two centuries Newtonian physics was held in

awe as a coherent description of the world we live in. However, towards the end of the nineteenth century certain experimental findings and theoretical considerations raised problems that Newton's principles couldn't handle. Physicists started looking for a new approach. Which is why Einstein's special relativity was well accepted right away, in spite, or maybe because, of its apparent revolutionary character.

In contrast, the step he took about a decade later was not at first so well accepted. In a series of lectures in Berlin in 1916 Einstein presented what is now known as General Relativity Theory. This was an all out revolution. The need for it was not immediately recognized and some of its tenets seemed to be utterly counter-intuitive and counter-logical. To begin with, according to Einstein's new theory the most significant and most encompassing feature of our existence – the space where we live (!) - is not what our intuition (and Newton) tells us it is. In particular, it is not governed by the rules of the fourth century BC's Greek mathematician Euclid, but by those of his eighteenth century AD's German counterpart Riemann. In a Euclidean space parallels never meet and the shortest distance between two points is a straight line segment. What can be more counter-intuitive than rejecting these postulates? Yet they are indeed rejected in a Riemannian space where there are different 'curvatures' in different sections of the space.

General Relativity Theory tells us that the gravitation induced by a large heavenly body (such as our Sun, for instance) shapes curvature around this body. As a result light rays passing near such a body are 'bent'. That is, they change their course of movement as if they are attracted to the gravitating body. But, many physicists argued between the years 1916 and 1919, light is energy, it has no mass, so it cannot possibly be influenced by gravitation. The notion of bending light rays seemed to be mere fantasy. And it was precisely this fantasy that Eddington set out to chase.

IV. TESTING THE THEORY

It might at first appear to be easy to test the hypothesis that light rays bend when they travel near, say, the Sun. All one has to do is track rays flowing down from a star 'above' the Sun, to see if they change course along the way. If Einstein is right then such rays should hit Planet Earth not exactly at the point where they should hit it if their course of movement is a straight line. So go out, turn your eyes, or any other appropriate instrument, to a star behind the Sun and see what happens to the light rays it emits.
But, of course, the problem is that at night you can see the stars but not the Sun and at day time you can see the Sun but not the stars. So what can be done? Well, the answer is simple – find a time which neither day nor night. Simple answer? Is there such a time? Well, yes, there is such time – the time of total solar eclipse. The Sun is then out, above our heads, yet darkness reigns and stars peeping from behind the Sun can be observed.

It turned out that in 1917/18, when the controversy surrounding general relativity peaked, a total solar eclipse was expected over parts of Africa and South America May 29, 1919. Scientists figured that the Sun will then be spotted as located at the center of the Hyades cluster, containing some of the brightest stars in Planet Earth's sky. The situation will be ideal for testing the bending light conjecture. Preparations then began in England to send teams of scientists to Sobral in Brazil's northern state of Ceara and to Principe Island in the Gulf of Guinea off the coast of West Africa. These two places were singled out through calculations showing that they would be most fitting for observing the anticipated solar eclipse. The scientific expeditions were organized by Sir Arthur Eddington, physicist and chief astronomer at Cambridge University, and he himself led the one dispatched to Principe Island.

Tensions grew high as preparations for the two teams' departure proceeded in late 1918. World War I was still raging, military concerns took top priority in British industry and pure science was relegated to secondary position. When the war ended, in November 1918, no more than four or five months were left for manufacturing the necessary equipment and making the final arrangements. The world's scientific community waited anxiously to see whether or not the planned ordeal will materialize, and if it does what will be the answers it brings. Einstein himself seemed to have been the only person who wasn't too worried and excited. When asked what he will say if the observations and measurements taken by Eddington's Expedition won't agree with his theory he replied: "Then I would feel sorry for the good Lord. The theory is correct." There is no arrogance in these words. Einstein truly and firmly believed that if a theory is logically and mathematically well founded then its laws must be obeyed, or else nature is at fault.

Similar kind of 'logic' can be found in Kästner's book. Conrad and company encounter Princess Parsley chased by a whale through the forest. They don't understand how a whale can travel on land. The little princess then explains that whales are mammals and mammals are land creatures, hence whales' living in the oceans is nothing but a clumsy error of nature. Returning now to our main story, luckily the war ended in time for the two teams to embark upon their missions. Eddington's team arrived at Principe Island about one month ahead of time and set the measurement instruments in place, ready for the task.

Once again tensions rose high as heavy clouds covered the sky in the hours before the eclipse. Luckily these clouds dispersed in time for the observations to take place at the right moment.

Eddington's crew, using one of the most massive and potent telescopes of their time, took pictures of the sky around the Sun when the eclipse reached the point of full coverage. These pictures were then set against pictures of the sky taken at the same site after nightfall. And lo and behold, at the time of total eclipse the bright stars of the Hyades cluster seemed to have (very slightly) shifted from their usual location.

Stars seemingly shifting may sound like another tale of fantasy. But this is precisely what general relativity decreed and predicted. At night a light ray from a Hyades star travelled along a straight line, hitting ground and the telescopic camera at the end point of that line. During eclipse, on the other hand, a light ray from the same star hit the camera at a different point, as it didn't travel along a straight line all the way through. When passing near the Sun it 'bent' and changed its course of movement, under the impact of curvature induced by gravitation.

A few weeks after returning from Principe Island, Eddington presented his findings and conclusions at a meeting of the Royal Society of Science in London. From there they spread everywhere almost at the speed of light (non-bending, presumably) and overnight Einstein became an international cultural hero.

It should be noted that Newton's theory also predicts a shift in the apparent location of a star near the Sun in time of total solar eclipse, but the size of this shift is about half the size Einstein's theory predicts. Eddington's findings exhibited a shift whose size is much closer to Einstein's estimate than to Newton's.

Later on it was claimed by several scientists that Eddington may have been a bit too enthusiastic in his support of Einstein, that his findings were not as conclusive as he chose to portray them, and that he ignored the fact that the findings of the Sorbal team showed a different picture. However, more precise and better controlled experiments and observations were carried out in the following years, by numerous scientists in various parts of the world, and they all endorsed the stipulations of the theory of general relativity. And recent reexaminations of the settings, the tools and the measurements in Sorbal and Principe Island suggest that Eddington was right to consider those of Principe Island more reliable.

V. THE 29TH AND THE 35TH

As mentioned above, two ideas may be thought of as shared by Einstein and Kästner – the notion of time dilation and the decree that nature must obey theories (or rules). In addition it can be argued that on the 29th of May Eddington corroborated certain fantasies, some of which are reminiscent of glamorous inventions in Kästner's "35th of May". On the 29th of May Einstein's abstract mathematical formulations became concrete laws of the real world. On the 35th of May the Equator appeared as a concrete strip of metal stretching across the ocean and holding the world together. On the 29th of May Riemann's space varying curvature, seemingly nothing of substantive content, proved to be something of tangible impact. On the 35th of May nothing is something, with the big sign at the gate to the Land of the Cockaigne (land of plenty) announcing: "free entry – children half price". Still, the truly overwhelming fantasy is that of bending lights, curving spaces and shifting stars. All the more so as this fantasy is reality. It is science.

VI. CONCLUDING REMARKS

Eddington and Einstein kept in touch with each other from opposite sides of the hate barrier when their countries of birth, Britain and Germany, were arch-enemies in the devastating World War I. The Quaker and hence pacifist Eddington was against the war from the very beginning. Einstein refused to take back his German citizenship, which he had previously relinquished in favor of Swiss citizenship, when he heard that German soldiers were using gas weaponry in the battlefield. The Germans were hoping that Relativity Theory will deal a death blow to the ideas of the English scientist Newton. On their part the British commissioned Eddington's expeditions with a view to disprove Einstein's postulations. Eddington, however, was all but sure while sailing to Principe Island that he was about to show that Einstein was right. Presumably he knew by then that certain obscurities deciphered in Planet Mercury's orbit around the Sun could only be fully accounted for and explained by means of general relativity. Einstein was quoted as saying: "If my theory of relativity is proven correct Germany will claim me as a German and France will call me a citizen of the world. If my theory is proven incorrect France will say that I am a German and Germany will declare that I am a Jew." The vicious, horrifying, historical irony is that even though he proved to be right the German Nazis burnt his works calling them "Jewish Science". They also burnt Kästner's books, because as a humanist writer he was considered decadent. And one final remark: Before embarking upon his journey of endless fantasy Conrad tells his uncle that he was assigned the task of writing about the Southern Seas since being good in mathematics he must be lacking imagination. This is just one of many examples of Kästner's well known sense of humor. Now, as a physicist Einstein must also have known something about mathematics. Hence obviously he was void of any kind of creative imagination when he formed his innovative and visionary theories of relativity. And the distinguished astrophysicist Eddington had no imaginative powers whatsoever when he exquisitely popularized the

toughest scientific ideas and tenets in a series of memorable writings. Poor guys!

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