GIREP newsletter

Groupe international de recherche sur l'enseignement de la physique
International Research Group on Physics Teaching
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Dear GIREP members,

As your new President, elected at the 1998 GIREP conference in Duisburg, I would like to address all members and to point out some of the interesting and challenging tasks to be tackled in the future.

GIREP has an outstanding tradition in international cooperation in the field of teaching modern physics. It is a great honour and pleasure to work for this highly esteemed community of physics teachers from all over the world, especially now as we make the move into a new millennium. As the past GIREP President Karl Luchner put it, members of GIREP are not only physics teachers. Moreover, they are highly idealistic persons, combining expertise in very different fields.

A high degree of competence in the subject area of physics is one important prerequisite, being a great challenge in itself in view of the rapid and still accelerating pace of scientific and technological development. In addition to the progress within physics and to the important developments linking physics with inter- and transdisciplinary areas, we have to keep track of the broader contexts, into which our science is embedded and from which it emerges. In my view, this requires an intelligent balance between tradition and innovation. Physics as a mental challenge is driven by the conviction, that the universe is intelligible by the human mind. The search for unifying principles has been the grand theme, conserved throughout all changes during the development of modern science. As part of our cultural heritage, we have to convey the “big ideas” of our discipline and make them accessible and sensible to our students in a meaningful and authentic way, which meets their expectations and needs.

Excellence on the physics side has to be complemented with excellence in terms of pedagogy. Switching the focus from physics to teaching, we have to acknowledge, that during the last decades significant progress has been achieved in research on teaching and learning processes and on using new technologies for teaching and learning. However, a great deal of this valuable knowledge has not been transformed to practical implementations on a broad scale. We still have to try hard to put together threads from different directions, matching the physics oriented view and the learner oriented view on various levels.

Science in general and especially physics has been under severe pressure in the last decades, suffering from declining students’ interest and enrolments. We are faced with the paradoxical situation of living in a society based on science and technology, the base of which is seemingly thinned out and the gap between the notorious “two cul
even increasing. The role of scientific literacy and the public understanding of science have become political issues in view of a globally linked society where knowledge plays an eminent role. As a reaction, different countries have launched programs to promote the quality of science education. Being involved in a national effort to improve the efficiency of mathematics and science education myself, I consider it one of the aims of future GIREP conferences to share our experiences from these different efforts and to make them accessible to the community.

At present, an interesting development can be observed on the international level. Formerly, knowledge used to be transferred from the developed countries to the less developed ones. This situation is about to change: nations, which were newcomers one generation ago, have made a superb progress and have reached a stage, where in turn the developed countries can profit from their approaches and their experience.

Let us take this as an indicator for the GIREP philosophy that international cooperation and cross-cultural exchange combined with idealism and enthusiasm will pay in the long run and will help to further the image of physics both as an intellectual endeavour and as one of the central pillars of our modern culture.

Manfred Euler

Mirror in orbit to illuminate small area of night-side of earth
- Remarks for purposes of physics teaching –

One of the future space technology projects is "Znamya 2,5": The project is to unfold a plane mirror (diameter 25 m) at high altitude from a space vehicle in orbit (about 400 km above ground), and to adjust this mirror properly to reflect sunlight to a selected area of the night-side of the earth, in order to illuminate it for a short time (http://www.energialtd.com/znamya.htm).

There are several interesting aspects to this project for the physics teacher: On the occasion of public reports on this project, he may spontaneously draw advantage from the public interest for his teaching; the physics behind it, as far as ray geometry is concerned, is simple, clear, and certainly covered in beginners physics courses; the questions connected with it are obvious and may be brought up and answered by the students themselves. Figure 1 shows the basic idea. The main questions arising will be: How big is the illuminated area? How will this illumination compare with the direct illumination by the sun (daylight)?

For further considerations, it is practical to employ the concept "virtual light source"; although the usual construction of the virtual image is not performed in Figure 2, the angle d° 0,53° describing the angular magnitude of the sun is sufficient. The (virtual) rays emerging from the virtual sun which arrive at the earth surface must pass the mirror; thus, the boundary conditions for the light rays are very similar to those produced by a pinhole camera: From all rays emerging at a certain point of the virtual sun, the mirror allows only a very narrow cone to reach earth surface; see dotted lines emerging at A. Because A is very far away, the dotted lines are almost parallel, and therefore the illuminated area around A'very closely corresponds to a parallel projection of the tilted mirror (d   M cos j). Now take into account all other points of the virtual sun: The illuminated areas corresponding to all source points between A and B will appear between A' to B'. In other words: The total illuminated area is a pinhole-image of the sun; its diameter is D and it is blurred by the magnitude d:

$$D = H\cdot d_{arc} = H\cdot d°\cdot 2\,p/360° \quad 3{,}7 \text{ km, with d about } 15 \pm 5 \text{ m}$$

The illuminated area of course moves, as the mirror in orbit moves; in order to maintain the illumination at a fixed area, it will be necessary to continuously adjust the orientation of the mirror. This will allow illumination at the fixed area for a period of the order of 10 minutes; otherwise the illumination there will last for less than one second.

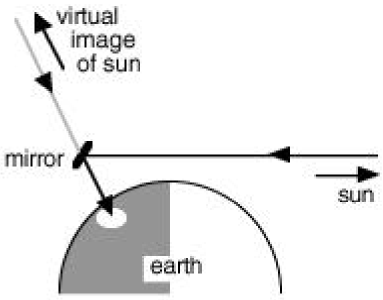

Fig.1 Illuminating a small region of the night-side by sunlight reflected from a mirror placed at high altitude.

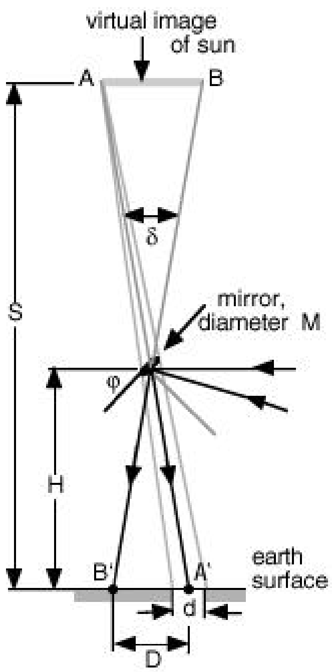

Fig.2 Visualising various light-beams, coming from the virtual image of the sun and passing the mirror on their way to the surface of the earth.
This drawing is not to scale: strongly enlarged is the angle δ, as well as the magnitude of M and H with respect to S.

In order to obtain some idea on the brightness of this illumination (illuminance, radiation energy received per second per unit area), let us take an observers position somewhere within the illuminated area, and have a look up to the mirror: It looks very small, much smaller than the sun. Would the mirror be much larger, the whole virtual image of the sun could be seen within, and accordingly the illumination would be equivalent to the full irradiation by the whole sun (ignoring small losses of the order of about 10% by the reflection). Since the angle d°

observer, the mirror would be large enough with a diameter M = H·d_{arc} 3,7 km or area 11·10^6 m^2 (if parallel to earth surface).

However, the real mirror is much smaller; with M = 25 m it has an area of about 5·10^2 m^2, which on account of the angle j is diminished to about 3,5·10^2 m^2. Thus, with this mirror only the fraction 3,5·10^2 /11·10^6 3·10^{-5} of the full sun irradiation is obtained in the illuminated area. This result is not as discouraging as it looks on the first view, if a comparison with the illumination provided by the full moon is made: Whereas the full sun provides 103.000 lux, the full moon provides 0,24 lux; this means, our 25-meter mirror produces an illumination equivalent to 3·10^{-5}·103.000 lux = 3,1 lux, which corresponds to illumination by about 13 full moons. With a follow-up project (mirror of M = 70 m) this would improve to about 100 full moons. Finally, one may suggest to reach improvement by employing a parabolic mirror in order to focuse, however this is reasonable only for very much larger mirror diameters. Focusing does not imply a change in D, but it implies a decrease in d: The focal length f would have to be f = H, and the size of the image would come out as before (D = f· d_{arc} = H· d°· 2 p/360° 3,7 km). However, with a large mirror diameter M without focusing the blurring d would come out large (d M), in the very same way as in the pinhole camera with a very large hole. This would mean loss of illumination to the central image area. Indeed, with a diameter of 25m there is practically no difference between a plane mirror and a parabolic mirror of focal length of 400 km (spherical radius 800 km).

K. Luchner, Sektion Physik, Universität München

Colloquium on Attainment in Physics at 16+

Invited delegates from eighteen European countries gathered at the National University of Ireland, Cork in September 1998 to examine and discuss the present state of teaching and learning in physics at senior secondary school level in Europe. The Colloquium, which was organised by the Irish Department of Education and Science with the support of the EU Socrates programme, was directed primarily at policy makers. The Colloquium organiser was Richard Coughlan, Senior Inspector, Department of Education and Science.

The general objectives of the Colloquium were (i) to report on the various approaches to physics education in the participating countries, (ii) to investigate the feasibility of carrying out international comparisons of standards in school physics and (iii) to formulate recommendations to national policy makers for developments in physics education.

Detailed background papers were provided in advance of the Colloquium by nine educational systems, namely Denmark, England and Wales, France, Finland, Greece, The Netherlands, Ireland (Republic), Northern Ireland and Scotland. Experts in physics education were appointed to examine and analyse these background 'country papers' and to present review papers to the Colloquium in each of four areas as follows.

Professor Paul Black, Kings College, London: Assessment

Professor Harrie Eijkelhof, Utrecht University: Social Issues

Professor Poul Thomsen, University of Aarhus: Curriculum Issues

Dr. John O'Brien, University of Limerick: Teacher Training

In addition, Professor Robin Millar, York University acted as general Rapporteur and reviewed the work of the Colloquium on the final morning.

As well as delegates from those countries which provided background papers, thirty nine other delegates attended, representing nine further European countries, namely Belgium, Bulgaria, Estonia, Latvia, Luxembourg, Poland, Slovenia, Switzerland and Spain.

Each session of the Colloquium included a presentation by one of the experts followed by two brief country presentations on the same theme. Following this, working groups explored different aspects of the theme under discussion and the session concluded with feedback from the working groups and a review by the expert. While this work programme was demanding, the delegates managed to enjoy a wide-ranging social programme and much good work was done and many contacts were made 'in the margins'.

While there is a very wide diversity of practice in physics education throughout the participating countries, it was interesting to discover how many problems were reported which were common to most or all of our educational systems. A decline in the number of students taking physics at the 16-19 stage and beyond was reported by many delegates; this was seen to be a problem, not a phenomenon to be noted with interest. A continuing failure to adjust the gender balance in the take up of physics at this level was also reported in many educational systems.

Considerable support was forthcoming from delegates for Poul Thomsen's assertion that distinction be made between the intended curriculum (stated aims and objectives), the implemented curriculum (what is actually taught - often driven by assessment criteria) and the attained curriculum (what pupils actually learn).

There was a broad consensus that any aspirations to improve physics education depend on the quality and commitment of the teaching force. The amount and quality of professional development (in-service training) varies considerably from country to country. Many educational systems also have to rely too heavily on teachers whose specific training in physics is minimal.

As well as dealing with the issues of falling interest and gender balance, Harrie Eijkelhof highlighted the increased amount of Science, Technology and Society (STS) topics which have appeared in 16+ physics syllabuses. Working groups, which were asked to consider how such material should be assessed, failed to come up with any solutions and reported back that 'no one seems to know'.

Because of the present wide diversity of practice, comparisons of standards between qualifications of the same age cohort in different educational systems seems still to be a long way off. A table presented by Paul Black, however, held out the hope of functioning as a template for some broad comparisons in the medium term. Many delegates and experts pointed to the need for more well-researched evidence on the relative reliability of conventional tests and of (carefully calibrated) teacher assessments at this level.

Robin Millar's overview of the Colloquium and the major recommendations of the experts will be published in the Colloquium Proceedings (to be put on the mailing list email *coughlanr@educ.irlgov.ie*). The expert papers, country background papers and other Colloquium materials will be published shortly on the Colloquium website:

http://www.irlgov.ie/educ/colloquium.htm. The Colloquium country papers provide a valuable source of information on educational structures and practices in the nine educational systems involved. One of the recommendations of the Colloquium is that consideration be given at EU level to create and maintain a concise information database on physics education practices in European countries in a reasonably accessible form.

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Physics of Star Trek: Detecting and Ranging in Spacetime to Avoid the Fall into an Invisible Black Hole

A Search for a Motivating Approach to Special and General Relativity

Alfred Pflug, University of Dortmund

1) **Relativity as a Science Fiction Story for the Young Generation**

Although our daily life is influenced in an increasing amount by technology, the corresponding basic scientific disciplines like physics and chemistry have to fight permanently to gain individual interest and public reputation. The number of physics classes in schools as well as the number of physics students at universities is permanently decreasing (at least in Germany) so that in several years a dramatic lack both of experts and of well educated laymen is unavoidable. Will the knowledge about the phenomena of nature be restricted, in the near future, to an elite of professionals who can manipulate the public opinion in a complete irrational way as in the Middle Ages?

We feel unable to answer this crucial question and propose instead an alternative approach to some items of physics, which are generally considered as interesting both for pupils and adults, but, at least in the general opinion, much too difficult for a treatment in schools or even introductory courses at university: we present a qualitative approach to the basic principles of General Relativity and the physics of Black Holes in the style of a Science Fiction story. The problem we want to describe could occur in every series of Star Trek: how can the commander of a spaceship avoid the fall into a Black Hole which cannot be seen directly in outer space by optical methods?

If we look at the usual formulation of Special Relativity as present in the majority of textbooks both for schools and universities, we will encounter very often global considerations: the whole configuration space is filled with a rigid (?) lattice of identical synchronised clocks joined with identically gauged rulers. It is rather difficult to generalise such an approach to a field theoretic and therefore strictly local description of Spacetime as it is done in the case of General Relativity. Therefore we will use a different type of event localisation already in Special Relativity, i.e. in a Spacetime which is flat „everywhere“, which means at every point in space for any time.

2) **An Operational Approach to Local Orientation in Space and Time**

We assume therefore a spacecraft with spherical symmetry, which contains in its centre a single clock (possibly a light clock, but also a conventional one) together with a point source of electromagnetic radiation (light, radar etc.) emitting temporally periodic radiation pulses in all spatial directions. We will call such a device a **PERPSER** (**P**eriodic **E**mitting and **R**eceiving **P**oint **S**ource of **E**lectromagnetic **R**adiation). Each individual pulse is (digitally) coded and contains the information about time and direction of its emission.

If such a pulse is received again in the centre of the ship, after a scattering by a space-time event which we try to localise, we can determine the radial distance of the scattering by the time difference between emission and reception of the coded signal and, simultaneously, the angular direction of the scattering by decoding the direction of emission. If the latter coincides with the direction of reception, a single scattering has occurred which we can localise in space.

By attributing the arithmetic mean value between reception and emission time to the time instant of scattering (which is a *mathematically useful, but physically somehow arbitrary definition* of *simultaneity for distant events, depending on the system of reference, i.e. the rest system of the radiation source*), we are able to determine the space-time co-ordinates in the (rest) system of the spaceship for any event considered (if we assume that electromagnetic radiation can be scattered by itself, as this is the case in Quantum Electrodynamics, at least for „large" frequencies).

3) **The (2 +1)-dimensional Minkowski Spacetime as a Euclidean 3-Space**

If we consider only a two-dimensional configuration space instead of a three-dimensional one and assume that we observe from our circular (instead of spherical) spacecraft how another circular spacecraft with nonvanishing relative velocity with respect to the original ship measures the distance to its own unit circle (instead of the corresponding sphere), we can interpret the events in the (2+1)-dimensional Spacetime as points in a Euclidean 3-space without referring to Minkowski geometry.

Only in this Euclidean language we are allowed to identify the propagation of light with the surface of a cone and the mass „shell" with a hyperboloid: in Minkowski language the light cone would be called a „Minkowski null surface" and the hyperboloid part of the „Minkowski unit sphere". From the Euclidean-geometrical representation of the distance-measuring by the spacecraft in relative motion to the observing spacecraft (using a **PERPSER** in both cases) we can understand, first qualitatively and finally quantitatively, the effects of

- relativity of simultaneity
- general, noncommutative velocity addition with arbitrary relative directions
- time dilation
- length contraction

As the speed of light is a universal constant, the discussion of velocity addition only needs the relativity of simultaneity as a prerequisite, but no other metric considerations like time dilation or length contraction. It appears here as the most fundamental property of relativistic observation, the noncommutative case can be treated as easily as the commutative one without the help of a Lorentz transformation. The limited length of this article does not allow to give any further details, which can be found e.g. in the references [Pflug, A.]

4) **Local Inertial Frames, Rotation and Tidal Forces**

As a (nonrotating) Black Hole cannot be detected by a **PERPSER**, because it is optically invisible and will therefore not scatter back any radiation (and absorb also all infalling massive objects as well), we have to use other methods to determine the position of the spacecraft relative to the Black Hole. To represent a **L**ocal **I**nertial **F**rame or **LIF**, the spacecraft should be shielded from outer force fields to guarantee a force-free inertial motion. For electric and magnetic field this can be done by a superconducting surface (Faraday cage and Meissner effect), because there are electric charges of both signs. Strong and Weak Forces have short range and can thus be exerted only by particles in the close neighbourhood. Therefore an absorbing lead shield (for charged particles), a neutron moderator and absorber and a vacuum chamber (for decaying particles) will eliminate these forces from outside in the interior of the ship.

The only fundamental force we cannot shield in the above manner is gravity, because the source of the latter is energy or, equivalently, mass, which is, under „normal“ circumstances, always positive (the only exception could be a nonvanishing scalar field in the - energetically renormalised - vacuum state which leads to a negative pressure and thus to a repulsive gravitation producing a cosmic „inflation“). But with the help of the Equivalence Principle, i.e. the mass-independence of the Spacetime orbit, we can eliminate gravity locally, i.e. in the centre of mass of the spacecraft, if the latter is falling freely, i.e. without rocket propulsion.

Is it possible for the spaceship commander to tell the difference between an inertial motion (weightlessness everywhere in the spacecraft), a (uniform) rotation in flat Spacetime (weightlessness along the axis of rotation and pseudogravity outside) and the free fall in a „real“ gravitation field (weightlessness in the centre, „tidal“ forces as a result of the gravitational inhomogenity outside)? There are in fact no „real“ strictly homogenous gravitational fields, because we cannot build a gravitational „capacitor“ only with positive masses, so that every „real“ gravitation field will be inhomogeneous and thus will show tidal effects outside the centre of mass of a (massive) body falling freely in this field.

If we assume that the spacecraft itself will not produce any own gravitation, the external gravitational field will have no sources inside the spacecraft and will therefore be called a „vacuum“ field. The latter has the property that every dust cloud initially at rest with respect to the spacecraft will not change its volume during its motion under the influence of the tidal forces generated by this „vacuum“ field. For infinitesimally short time intervals this is equivalent to the fact that the divergence of the tidal force field vanishes with respect to free falling systems. For simplicity we assume that we measure the volume change of a sphere with (massive) „dust“ particles on its surface centred initially around the mass centre of the spacecraft.

5) **Real versus Artificial Gravity**

Can we distinguish a „real“ gravitational field which leads to volume-preserving tidal forces outside its sources (both in the case of a free fall and for a jet propulsion which only adds a constant forces to the tidal ones) from a pure rotation in flat, i.e. gravity-free space, which is generally considered to produce „artificial“ gravitation? The answer is yes: also the rotation in flat space will produce a kind of „tidal“ forces.

These tidal forces vanish along the axis of rotation and are proportional to the (orthogonal) distance to the axis of rotation, as long as the velocity relative to the spacecraft is negligible; otherwise we have to introduce the velocity-dependent Coriolis forces (this shows clearly that it is much easier to specify their space-time orbit, which is a straight timelike line in the nonrotating system of reference). The important difference to the „real“ gravitational field lies in the fact that the volume of a dust cloud initially at rest with respect to the rotating system will strictly increase if it is released.

This is equivalent to a strictly positive divergence of the rotational tidal forces. Thus, in a „real“ gravitational field outside its sources, we can distinguish a rotation from the gravitational tidal forces and thus stop this rotation by the export of angular momentum. In this sense rotation is absolute also in General Relativity. Even for a stationary rotation, as this is the case for a spherical spacecraft, the „outward“ trajectory of a body (massive or not) is different from the inward one, as a comparison with the nonrotating inertial system immediately shows. Such a situation, which is invariant under time translation, but not time reflection, is called stationary. If the Spacetime orbit is, in addition, independent of the time direction, we call the situation static.

6) **Detecting an Invisible Black Hole from Local Observations in a Spacecraft**

6.1) **How can the Commander Avoid in Time the Fall into the Singularity?**

The idea to avoid a free fall into the singularity of a (Schwarzschild, i.e. nonrotating and uncharged) Black Hole is now the following: we want to „park“ the spacecra
in a fixed distance to the (invisible) Black Hole. For this purpose we have to answer at least four questions:

i) How can we detect an invisible Black Hole from *inside* the spacecraft? What happens if the Black hole forms a kind of double star with a noncollapsed object or a second Black Hole?

(In the sequel we exclude the case of three bodies bound by their mutual gravitation because this configuration is already unstable on the nonrelativistic level and will typically lead to the emission of one body to spatial infinity, unless there are „plane“ initial conditions and mass hierarchies as in our planetary system).

ii) What does the term „at rest“ (relative to the Black Hole) mean operationally for the crew of the spacecraft?

iii) How can we define a suitable distance to the (invisible!) Black hole? (in fact, it would be sufficient if we can decide whether two events occur at the „same“ distance from the Black Hole or not)

iv) How can we determine the mass, the angular momentum and the electric charge of a Black Hole from *inside* the spacecraft?

6.2) **Physical Suggestions to Solve the Commander's Problem**

Because of the restricted length of this article, we are not able to answer every question exhaustively, but we try to sketch the essential ideas:

ad **i)**

After having cancelled a possible rotation of the spacecraft by export of angular momentum, we shut off all its engines. Subsequently we observe - by piezoelectric sensors coupled to a massive body or by observing a possible tidal deformation of a released dust cloud on its path trough the spaceship - whether there are remaining tidal forces or not. If the answer is yes, we try to localise any source for the gravitational field which causes these tidal forces with the help of the **PERPSER**.

If it doesn't find any source at all (one or two black holes) or only a single one (noncollapsed massive object) which does not stay on the symmetry axis of the tidal deformation of the initially spherical dust surface, the commander of the spaceship should give „Black Hole Alarm".

If the tidal forces vectors are (quasi) periodic in time, the spacecraft is supposed to orbit around a source (which is assumed to be not totally visible). But as it is too dangerous to wait until these forces finally start to decrease, the commander of the spacecraft has to react immediately and „park" the spacecraft safely in a suitable distance from the source of gravitation, so that it is at rest with respect to this source and not in free fall towards or around the latter.

ad **ii)**

Because of the assumption that we have already eliminated the „internal" angular momentum of the spacecraft by measuring the divergence of the tidal forces inside the system we now have to eliminate the „external" angular momentum of the orbit around the (at least partially invisible!) source(s). Even if the orbit is a closed circle (which is only possible if there is a single source and not a double star system) the tidal forces will change their orientation (if not their magnitude as well) with time, because we can exclude, having eliminated the internal angular momentum, the case of a bound rotation, where the spacecraft is always facing the source. As we have not yet specified how to measure the distance to the source, the term „circle" is supposed to refer to the symmetry of the system and not to the metric aspect of that distance: an orbit is called circular if the tidal forces only change their orientation, but not their magnitude.

The symmetry axis of the tidal forces (or, more precisely, the direction to the maximum of the magnitude) will point to the source, but in a three-dimensional configuration space, there is a total plane of directions perpendicular to the orientation towards the source (and not a single direction as in the case of two spatial dimensions). As a test for the validity of our additional assumptions, the orientation of the tidal force on the surface at the location of the maximal (and also minimal) magnitude is radial, i.e. perpendicular to the (spherical) surface.

To determine the direction in which the motion around the (at least partially invisible) source(s) of gravitation takes place, we assume now for simplicity that we have already achieved a circular orbit around the source(s), i.e. only a rotational change in orientation of the tidal forces, but not in magnitude (for corresponding points, which are, as a matter a fact, not fixed points on the surface of the spacecraft!). If such an orbit cannot be realised, we know that there must be more than one single source of gravitation.

Let us therefore assume for simplicity that there is only one (invisible) source of gravitation and that at least one circular orbit around this source is possible, i.e. the tidal force field is only rotated over the surface of the spacecraft without a change in magnitude for corresponding points (not for fixed points on the surface!). The direction of the maximum of magnitude of this tidal force field points to the gravitational source.

If we register the orbit of this maximum (which is a continuous curve and not only a single point, because the spacecraft is assumed not to rotate!) on the spherical surface of the spacecraft, we get a great circle, i.e. the intersection of the sphere with a Euclidean plane containing the centre of the spacecraft. This plane is also the plane of the orbit. Both the „real“ orbit circle as well as its circular „projection“ on the „spherical“ surface of the spacecraft will be run through with constant angular velocity, which is not the case for truly (quasi) elliptical orbits.

To determine the orientation of the orbital angular momentum (which is necessary if we want to export this angular momentum to „park“ the spacecraft at „rest“ with respect to the source of gravitation), we note that the actual direction of motion is given by an oriented line from the centre to a point on the orbit of the tidal maximum as described above, which runs under an relative angle of $\pi/2$ or 90° behind this maximum with the same angular velocity as the latter.

The same orientation is necessary for a propulsion nozzle which should reduce the orbital angular momentum to zero. Simultaneously another propulsion nozzle oriented towards the tidal maximum should stop the free fall into the singularity. Its permanent, time-independent rate of firing is chosen in the way that the tidal force field becomes static (and thus will not move any more relative to the spacecraft), but it will give rise to a nonvanishing gravity everywhere in the spacecraft. Such a position will be called „at rest“ with respect to the invisible source of gravitation.

It is rather clear the assumption of a circular orbit can be weakened: the orbit of the tidal maximum will always be a circle because of the plane nature of the orbit in space around the gravitational source. In the general elliptic case the tidal force field will not only be rotated during the motion, but also be deformed in magnitude and the angular velocity of this motion will not longer be constant. The above construction to find the actual direction of motion using the relative angle of 90° with respect to the tidal maximum can now only performed in the periastron (or apastron), which represents the absolute maximum (or minimum) point over the whole orbit of the actual tidal maximum.

ad **iii)**

By changing the rate of the radially oriented thrust of the spacecraft at „rest“ with respect to the Black Hole, we can change the distance to the singularity. The maximum of the tidal forces (which are static with respect to the spacecraft at „rest“ relative to the gravitational source) increases with decreasing radial distance. If we want to determine the Schwarzschild radial co-ordinate in a quantitative exact way, we can park the spacecraft in such a distance to the black hole that the **PERPSER** suddenly gets a backscattered signal which arrives from exactly the opposite direction compared to its emission.

Such a backscattering means that a circular light orbit will result, because for all other orbits, perihelion precession will prevent strictly closed orbits – after a full cycle there will be a „kink“ in the direction of the orbiting object, be it light or a massive body. For such a parking position with circular light orbits, the Schwarzschild radial distance R_c from the centre is

$$\mathbf{R_c = c^{x}Dt_c /2p}$$

where c is the magnitude of the light velocity and Δt_c is the time interval between emission and reception of the light pulse, measured with the local clock inside the spacecraft.

As a matter of fact, we could approach the singularity even closer than R_c, as long we park the spacecraft outside the Schwarzschild horizon which is located at the Schwarzschild radial co-ordinate $R_s= 2/3\cdot R_c$. If a spacecraft would be parked on this horizon at $R = R_s$, a radial outward light pulse would remain „at rest“ relative to this spacecraft, which would violate Maxwell’s equations.

Of course, the necessary thrust to park the spacecraft at $R = R_c$ will be enormous even for a Supermassive Black Hole of a million of sun masses as we suppose it to be found in the core of our galaxy. In order that the gravitational acceleration inside the spacecraft parked at $R = R_c$ should be of the order of 1 g, the mass of the Black Hole would necessarily equal the mass of roughly 30 galaxies, each with 10^{11} sun masses.

If we use, instead of the **PERPSER**, a kind of particle gun emitting massive bodies with velocities of magnitude v in all directions, we can, similarly to the above construction, look for a „rest“ position relative to the gravitational source where these particles are „scattered“ back in the opposite direction of their emission. The Schwarzschild radial co-ordinate of this position would then be

$$\mathbf{R_v = v^{x}Dt_v /2p}$$

in complete analogy to the above situation for massless bodies.

It is interesting to note that the tidal force inside a spacecraft which falls freely through the Schwarzschild Horizon at $R = R_s$, always stays finite. In this case light will always move relative to this falling spacecraft even if it cannot cross the Horizon from inside. For the Supermassive Black Hole in the galactic centre (with a million sun masses), the tidal accelerations at the Horizon will be much less than 1 g, if the spacecraft is smaller than 100 meter in radius.

ad **iv**)

To determine the mass of the Black Hole, we can park the spacecraft either at $R = R_c$, then General Relativity gives for the Mass:

$$\mathbf{M = 1/3^{x}(c^2/G)^{x}(c^{x}Dt_c /2p)}$$

where the notation is as above (se ad iii). If the necessary thrust is too large at this position, we can also go to very great distances where Newtonian gravity theory applies and get

$$\mathbf{M = \lim_{v \to 0} (v^2/G) \times (v \times \Delta t_v / 2\pi)}$$

where the first factor tends to zero, whereas the second one, which corresponds to the Schwarzschild radial co-ordinate R_v, tends to infinity. We see that, besides the factor 1/3, the relativistic expression coincides with the asymptotic nonrelativistic limit.

For the reason of simplicity, we will only discuss the case how we can distinguish the spherically symmetric case with vanishing angular momentum of the Black Hole from the breaking of this symmetry. If the backscattering of light (or massive particles) at $R = R_c$ (or $R = R_v$) occurs symmetrically in a plane perpendicular to the thrust, the situation is spherically symmetric and the angular momentum vanishes.

The Charge of a Black Hole will generate an electric field in the whole space which carries energy. Therefore we do not have the outside vacuum field we have assumed throughout this paper. An external electric field can be detected on the surface of the spacecraft and shielded by metallic boundary conditions, so that the internal tidal forces will not be affected.

We omit deliberately the situation, where both charge and angular momentum of the Black Hole will not vanish, because it seems much too complex for this article.

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Report from the international conference 'Turning the Challenge into Opportunities: the Historic Mission of the Physics Teacher for the Next Millennium', August 19 - 23, 1999 in Guilin, China.

This was the first conference outside of Europe which GIREP recommended (with the exception of one conference in Israel). This is not only a sign of the growing internationality of the physics teaching community but also of the increasing importance of the Asian region. Organized by Professor Luo Xingkai from the Institute of Physics Education at the Guangxi Normal University, the conference was attended by more than 250 physics teachers from all over the world. Although there were certain language difficulties in communicating intensively between nonChinese and Chinese participants, who of course constituted the main part of the attendees, new international connections were established. Only a few plenary lectures were hold. The focus was placed successfully on workshops, poster sessions and exhibitions with interactive participation. I believe we should concentrate more on this type of presentation. A public evening lecture in an open-air theatre, given jointly by W. Buerger/Germany, Janchai Yingprayoon/Thailand and Y. Takikawa/Japan, demonstrated a broad spectrum of presentations. The social program was excellent. All the participants appreciated the warm and helpful support. I can certainly recommend travelling to Guilin, even without a conference.
Details of the conference can be seen under the URL: http://www.ipe.gxnu.edu.cn/
Proceedings of the conference will be published in English and in Chinese. Please contact Professor Luo XingKai: xkluo@osmanthus.gxnu.edu.cn

C. Ucke, Munich

Second European Conference on
'Physics Teaching in Engineering Education' PTEE 2000
14-17 June 2000, Budapest, Hungary
Organised by the Technical University of Budapest under auspices of SEFI

The Second European Conference on Physics Teaching in Engineering Education 2000 follows the first conference PTEE 1997 held under the auspices of the Societë Europëenne pour la Formation des Ingënieurs (SEFI) and European Physical Society (EPS) at the Engineering College of Copenhagen, attended by over 150 participants. The scope of the PTEE 2000 conference will include all aspects of physics teaching in engineering education. The aim of the conference is to bring together people working in this field from different parts of Europe, to provide them with a forum for the exchange of ideas and experiences.

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Conference e-mail: ptee2000@phy.bme.hu
Conference website: http://www.bme.hu/ptee2000

Please send contributions for the next GIREP Newsletter till 15 January 2000!

PHYTEB
PHYSICS TEACHER EDUCATION BEYOND 2000

The XVIII edition of the GIREP International Conference will be held in **Barcelona** from the **27th of August to the 1st of September of the year 2000,** supported by ICPE, the European Commission DGXII, the Spanish Ministerio de Educación y Ciencia, the Departament d'Ensenyament de la Generalitat de Catalunya and the Universitat Autònoma de Barcelona.

It is generally well accepted the necessity of well trained Scientists and Technicians to deal with the challenges that come with the new millennium. On the other hand, a great effort has to be undertaken to achieve a satisfactory level of Science and Technology literacy for all citizens. Both the training of expert Scientists and researchers, and a satisfactory level of Scientific and Technological literacy for the citizenship, require a solid formation in Physics from basic levels to University.

To achieve this consistent education in Physics, three main objectives should be considered: a revision of the Physic contents, innovations in the didactical resources and teachers with a high Scientific and Educational training. The last one is the most important as both new contents and innovations need prepared teachers to implement them successfully.

The PHYTEB Conference has the aim to create a favourable frame to bring together professionals from the field of Physics, Physics Education (at all levels) and Physics Teacher training. The opportunity to meet together and discuss the current situation of Science and new ways to deal with Teachers Training and Physics Teaching is extraordinarily fruitful and brings a great enrichment for both collectives.

The results obtained by researches and studies presented in the Conference should propitiate a better formation of teachers, an adaptation and innovation of education contents, and methodology, guidelines and resources for Physics teaching.

Conference Topics

Physics beyond 2000: **New contents for a new conception of Physics Teaching.**

- What Physics should be taught?
- Basic concepts and structure of Physics
- Relationship between current Physics in research and Physics in School.
- Scientific contents in Physics Education
- Scientific contents in Physics Teacher Education
- School-University interaction

Teacher Education beyond 2000: **Improving Physics Teacher Education**

- Guidelines and approaches: how should Physics teachers be trained?
- Professional contents for Physics teachers
- Strategies to improve
- In-service Teacher training
- Collaborative work

Physics Education beyond 2000: **Physics Education, new methods and tools**

- How should Physics be taught?
- Innovative methods, strategies and contents
- Computer based/aided learning
- The impact of other new technologies in Physics teaching
- Approaches of the Labwork
- Assessment procedures.

On these three topics there will be lectures, communications, brief contributions and posters.

Organisation
The GIREP 2000 International Conference "Physics Education Beyond 2000" is jointly organised by the Science Education Department and the Physics Department of the Universitat Autònoma de Barcelona, UAB.
The co-ordinators are:
Dra. Roser Pintó and **Dr. Santiago Suriñach**.

Conference fees (before April 30th):
GIREP members : 160 euro
Non-GIREP members: 180 euro
Students*: 100 euro
* See conditions in the web page

Social programme
There are also some entertainment and tourist activities planned in addition to the official activities, that contribute to a better knowledge of our country and culture. The city of Barcelona has many cultural and leisure possibilities and is very attractive to foreign visitors.

Contact the Organising Committee by **e-mail** at:
<Miquel.Munoz@uab.es>
<Digna.Couso@uab.es>

More updated information in our Homepage. Please visit us at:
http://www.blues.uab.es/phyteb

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FEES

The accounting year runs from January 1 to January 1. Fees paid after September in any year will be credited on the following year, unless the applicant specifies otherwise.
The current fee (1999) is 12 GBP (GBP = British Pounds Sterling), EURO 17 or USD 18 preferably paid into the following account:
Christian Ucke, Postbank (GIRO) Muenchen, Account No. 355 28-808, BLZ 700 100 80.
BLZ (= BankLeitZahl) means a special sort of code for the Postbank in Germany.
Please do not pay into other accounts.
The members should pay their own bank charges and mailing costs. At the same time, please send a note (by letter, fax or e-mail) to the Treasurer, confirming how much money you sent and when and for what years.
In some countries, it is possible to transfer money from the national **Post**bank with EUROGIRO free of charge (Belgium, Germany, Japan, Luxembourg, Switzerland, Spain) or with a small charge (Denmark, Finland, France, Great Britain, Netherlands, Austria, Sweden).
If you send a EUROCHEQUE filled out in DEM, there are no expenses at all for the Treasurer. If you send a cheque filled in your local currency, there are DEM 3 (Euro 1.50) expenses for the Treasurer. Please do not send cheques drawn on a bank from your country (except UK) but filled out in GBP (horrible expenses then).
If you prefer to reduce bank expenses, you may pay several years fees in advance.
It is also possible to pay by credit card (EURO-/MASTERCARD or VISA; no others). Please write or fax to the Treasurer your full card number, expiration date and the amount. Add 5% expenses to the amount. The Treasurer will convert that amount into DEM and then charge your credit card account in DEM.
It is not recommended to use e-mail for sending credit card numbers.
In cases of real difficulty to arrange payment, please contact the Secretary or the Treasurer who are ready to advise whether special arrangements can be made.
The General Assembly of GIREP members in Udine (August 1995) accepted the following supplementary new article for the GIREP statutes:
Each year in October, those members who have not paid for the previous two years will be removed from the membership list.

Look at our home page http://www.pef.uni-lj.si/girep and fill in the members' form!
User name: girep, password: duis98