14ème th SIIV IFIS
Toulouse-France 12-16 Juin/June 2006

A new approach to cost-effective digital precision inertial positioning (DPIP)

Dr. M. Böhm
Telphykas
Solitudestr. 389
70499 Stuttgart, Germany
E-mail: dr.boehm-telphykas@t-online.de
Tel. 49-(0)711-831131
Fax 49-(0)711-831124

SUMMARY

Based upon physical insight 1) deepened re-cently, a new approach to digital precision inertial positioning (DPIP) without light is presented which combines highest precision with comparatively lowest cost. Application is envisaged for the automotive industry, but for defence applications as well. And, of course, flight inspection is also an important field of beneficial potential applications.

INTRODUCTION

Positioning at present is based upon numerous approaches which have partly overcome from history, while others, like Galileo, employ all knowledge and technology available at present. There is no one world-wide positioning stand- ard for all mobile users, although GPS and Galileo may grow into such a position (fig.2).

Traditionally positioning has been based upon what the human eye could see, during day and night. Lighthouses are still around in quite many varieties and quantities. And, by the way, all monitoring functions eventually rely upon the human eye.

With the evolvement of radio aids many standards became available for enroute navigation and, in particular, for safe landing under all weather conditions. Used frequencies range from Kilohertz to Gigahertz.

For defence inertial navigation devices were developed, which cannot be jammed. Very expensive originally, they have found many applications also in civil aviation. Highly accurate rate sensing based upon ring laser gyros is employed in many aircraft and also ships. Application within civil wheeled vehic-les is too expensive yet.

It has to be emphasised that up to now no direct inertial velocity measurement is consi-dered to be possible, due to the impact of the Lorentz transformation. This view, however, has to be changed.

NEW PHYSICAL BACKGROUND

In march 06 at a DPG convention in Munich a paper [1)] was given intended to solve the riddle of gravitation. The author called the giving up of the ether concept after the Michelson-Morley null result a strategically wrong deci-sion of physicists, since the recognition of quantum ether apparently answers more open questions than any other physical concept, not just those asked for gravitation.

The very door opener to the new quantum ether is the quantum-Hall-effect [2)], well known from solid-state technologies, and the Von-Klitzing-coefficient Ak which combines the Planck quantum h and the electron e as the natural law $h = e^2 A_k$ (fig.3). If one assumes permanent quantae $\underline{h}$, which have the unit Joule as opposed to Js for sequential quantae, the law changes to $\underline{h} = e \bullet \underline{u} = e \bullet i \bullet A_k$ which defines energy particles of a geocentric quantum ether. The energy content of one cubic meter of quantum ether is 8,3 J. A second message of the Munich paper is the advise not to further pursue a gravitation constant G but a variable gravitation coeffi-cient $G_i^* = ß^2\alpha/\varepsilon^2$ (fig.3).

The postulation of a geocentric quantum ether leads to interesting conclusions with respect to sun and earth motions (fig. 4). For instance, it can be derived why planets follow elliptic orbits and what a role their daily rotation plays in that process. This, however, is not topic of the paper presented here.

But the geocentric quantum ether allows for a new look at the experiments of Michelson-Morley [3)] (fig.5). They always delivered null results, and it was therefore concluded that there is no ether [4)]. This conclusion, however, only denied a stationary space ether and disregarded the possibility of a geocentric ether as the reason for the null results. In fact, the stationary MM interferometer null result can be taken as the proof of a geocentric quantum ether. If one designs a mobile MM interfero-meter instead, there will be no null result but a frequency difference between the signals of both arms. This opens the door to inertial velocity measurement on earth. An important aspect of the Lorentz transformation has always to be kept in mind: EM waves invariably travel with c within the ether, but the losses grow with each reflection at reflectors moving within the quantum ether. And if, in addition, the direction of a beam is changed, the loss grows further. Since each loss results in a reduction of frequency, this is reduced with each reflection at an object moving within the ether. Thus there is no reason to look for eventual changes of light velocity. Every red shift is due to losses, but not caused by any change of c.

INERTIAL VELOCITY MEASUREMENT

Fig.6 shows how an inertial velocity measure-ment can be performed all digitally by using a digital counter.

The underlying consideration is that in optics each reflection of a light beam at a moving mirror causes a loss of $(ß^2/2)h$, with a respective reduction of frequency ν of a photon. Were there 10^3 reflections in succession, the losses would increase by the same factor which would be also valid for the resulting decrease of frequency, i.e. increase of red shift of light.

While using light and many reflections is a reasonable approach for an inertial veloci-meter design, it would still be an analogue approach to which a digital approach is to be preferred for a number of reasons. In order, however, to understand how it works, the following consideration has to be made. Light travels $3 \cdot 10^8$ meters in a second. An EM signal in a digital counter with say 37 stages, a length of 3 cm and a clock of 10^{11} Hz travels only 3 cm in a second from the input to the output which equals a velocity of $c^* = 0{,}03$ m/s. Thus the ratio c/c^* is 10^{10}, and the square of that is 10^{20}. If this figure is multiplied with $ß^2/2$ one gets, for a velocity of 1 m/s, $1{,}65 \cdot 10^3$ bits/s, and even with a repetition rate of 10/s a figure of 165 from which the velocity 1 m/s can easily be calculated. This example indicates how digital inertial velocity measurement (which not even relies upon the geocentric quantum ether) can be flexibly adapted to any application.

INERTIAL ROTATION RATE MEASUREMENT

Inertial rate sensing is not new since the experiments of Sagnac. Using light for that in ring lasers and fibre gyros are well known and proven approaches which, by the way, can also be taken as proof for the geocentric ether.

A digital approach using counters only, however, has not been advised up to now. As fig. 7 indicates a fully digital approach without using laser light is expected to lead to a drastic reduction of effort for similar performance levels as achieved by available analogue devices.

A digital rate sensor has to comprise at least three double counters arranged in a triangle for each coordinate. For simplicity the arrange-ment in fig. 7 comprises four double counters each arranged to be one side of a square, with a clock in its centre. There is also a comparator to process the respective contents of each counter pair.

When the arrangement is moving and rotating, the counters contain the results of both motions with v and vr. But while the vectors of v do not change their directions at any point in time for the four sides of the square, the vr vector directions are different for each side. Therefore the respective sums of both vectors at all four clock feeding points of the four double counters are different, and so are the 2nd order Doppler effects and therefore the counting results. From these v is eliminated during processing by respective subtraction, and vr remains which delivers the rate in that very moment. The equation used is $0{,}5\ (n_1^{1/2} - n_2^{1/2})$ for v_r. But also v can be determined, via the equation $0{,}5\ (n_1^{1/2} + n_2^{1/2})$, with n_1 and n_2 being the contents of counters 1 and 2 of each pair.

As fig.7 indicates, rates of 10^{-2} and even 10^{-3} of the earth rate can be measured with comparatively modest technical effort, com-pared with ring lasers.

NEW DIGITAL INERTIAL PRECISION POSITIONING

Future precision positioning is assumed to be fully based upon solid state technologies without any light (except for displays for the users), as shown in fig.8. A digital precision inertial positioner DPIP with a volume of say 0,1 litres in essence contains three pieces of the Doppler square ring counter (DSRC) version shown in fig. 7, arranged orthogonally to each other and fed by a common clock. Comparison of the respective contents of the twelve counters delivers three orthogonal velocities plus three orthogonal rates. And by using these data a precision position track can be derived as well as full continuous attitude control.

COMPARISONS

What can be expected from the new approach to digital precision inertial positioning (DPIP) outlined before? The answers are given as coarse overviews in fig. 9 and fig. 10.

The general comparison is on performance, weight & volume, and probable cost for respective radio equipment, analogue inertial and digital precision inertial positioning equipment. It has to be emphasised that only cost for the user equipment is considered, not system cost. That means for GPS, for example, the exclusion of space section as well as ground control cost.

For comparable performance, the expected cost spread and also that of weight and volume is quite substantial as can be taken from the given ratios (fig.9). Of course, these benefits will not come overnight to the interested customers. But the inherent potential will become reality within less than a decade.

Some selling points of the approach outlined here are listed in fig. 10.

STATUS & TIME SCALE

When can respective products for interested customers be expected? The answer is given in Fig.11. It is: Two IFIS convention intervals. During 2006 the first experiments with a mobile Michelson interferometer will be performed, while experiments with a digital inertial velocimeter will be performed during 2007, to be followed by digital inertial rate sensing. The first digital precision positioner DPIP prototype is expected to become available during the course of 2008, with the first products being on market in 2009. A product family for different customers will become available during 2010.

A number of problems has still to be solved, related to quality of products, as opposed to just demonstrate new physical phenomena. Not the least problem concerns reliable simple software.

CONCLUSIONS

DPIP is expected to open the gate to a family of new products for a wide field of classic as well as new applications like indicated in Fig.12. The automotive industry may eventually become the most important customer on land, but also the construction business with its heavy machinery deserves a close look. On the seas there are many ship owners who might be in favour of affordable inertial precision positioning, supplementing the existing radio equipment. Air customers have many different requirements, the most ambitious ones certainly being those involved in IFIS activities. And there may also be some space customers, interested in experimental as well as operational applications. In general it can be noticed that an old physical effect, understood really after a close look, has the potential to open the way to many new business opportunities.

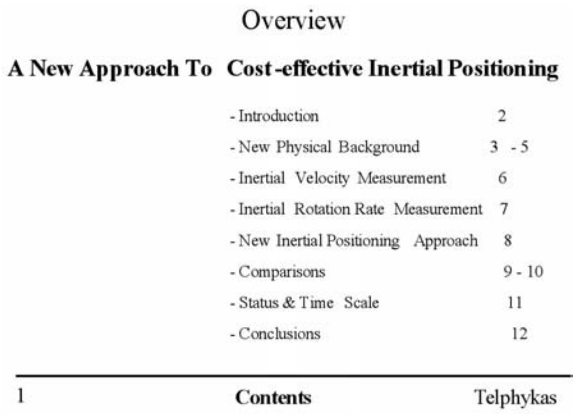
REFERENCES

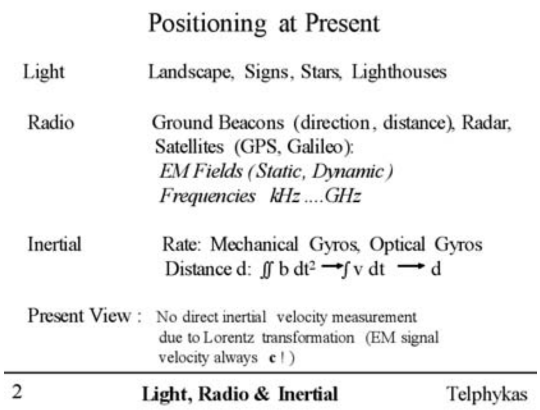
1. Böhm, M.: Von G zu Gi*; Gravitation als elektromagnetische Quantenwirkung; DPG (°) spring convention, paper GR 404.7, Munich 2006

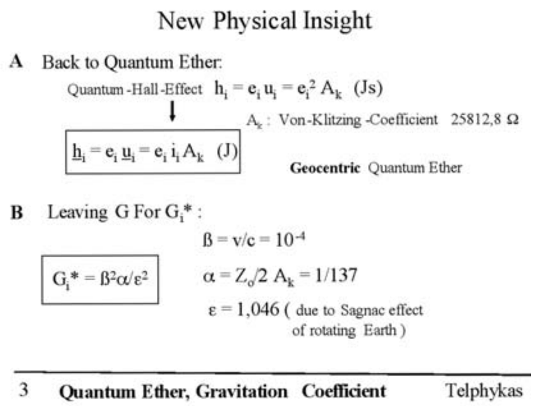
2. Quanten-Hall-Effekt: Bergmann Schaefer, Lehrbuch der Experimentalphysik, Bd. 6: Festkörper, S.598 –602

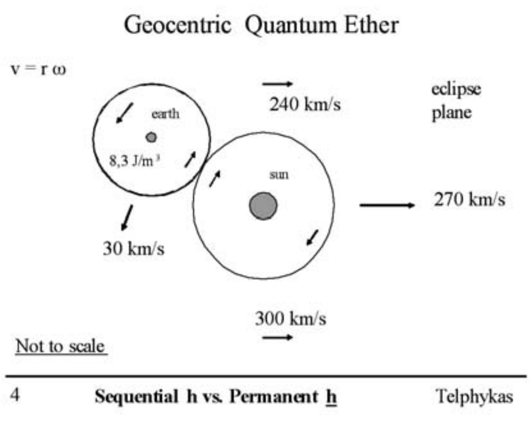
3. Peters, A.: A modern Michelson-Morley experiment using ultrastable optical resonators DPG (°) spring convention, paper GR 202.1, Munich 2006

4. Äther, brockhaus, physik. Bd.1, S.45, Leipzig 1989









A New Look at Michelson-Morley

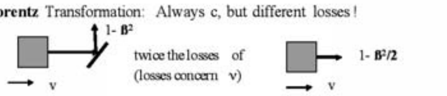
Stationary : No differential velocity between interferometer & geocentric quantum ether

Transversal: $2l/c(1-\beta^2)^{1/2} = 2(1+\beta^2/2)\,t$
Longitudinal: $2l/c(1-\beta^2/2) = 2(1+\beta^2/2)\,t$ — no difference

Mobile : Differential velocity between interferometer & geocentric quantum ether

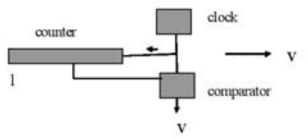
Transversal: $2l(1+\beta^2)^{1/2}/c(1-\beta^2)^{1/2} = 2(1+\beta^2)\,t$
Longitudinal: $2l/c(1-\beta^2/2) = 2(1+\beta^2/2)\,t$ — difference $\beta^2/2$

Lorentz Transformation: Always c, but different losses!



5 **Stationary vs. Mobile** Telphykas

Digital Inertial Velocity Measurement



$\beta^{*2}/2 = 1650$

v ▶ 28,7 pro 1 m/s

conventional approach : $1-\beta^2/2$; $\beta = v/c$; v = 1 m/s: $\beta^2/2 = 1{,}65 \cdot 10^{-17}$

2nd order Doppler effect

l = 0,03 m; 10^{11} bit/s ⟶ 37 stages

$c = 3 \cdot 10^8$ m/s; $c^* = 3 \cdot 10^{-2}$ m/s

new approach : $\beta^* = (c/c^*)\,\beta$ ⟶ $10^{10}\,\beta$ ⟶ $10^{20}\,\beta^2$

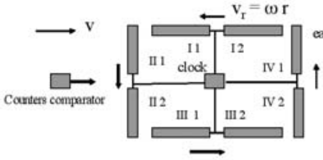
6 **Different Utilisation of Lorentz Transformation** Telphykas

Digital Inertial Rotation Rate Measurement

At present **analogue** : - Ring Laser Gyro
(**1st** order Doppler) - Fiber Gyro

future : **Digital** square ring (DSR) counters (**2nd** order Doppler effect)

$v_r = \omega r$



earth rate (°/s): $4{,}17 \cdot 10^{-3} \cdot \beta^2/2 = 2{,}1 \cdot 10^{-11}$

r: 0,05 m; $v_r = 3{,}65 \cdot 10^{-9}$ m/s

$c/c^* = 10^{10}$

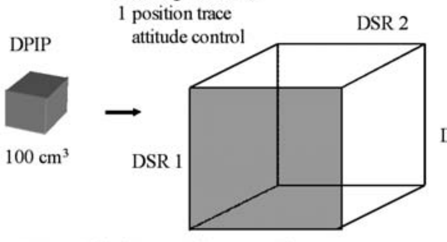
$c^* = 3 \cdot 10^{-2}$ m/s

earth rate	clock	counter l contents	Rate	velocity
1				
0,1	$10^{11}\ s^{-1}$	n_1, n_2	$\_\ (n_1^{1/2} - n_2^{1/2})$	$\_\ (n_1^{1/2} + n_2^{1/2})$
0,01				
0,001				

7 **Potential Sagnac Competition** Telphykas

A New Positioning Approach

3 orthogonal velocities
3 orthogonal rates
1 position trace
attitude control



DSR : Digital Square Ring (see Fig.7)

8 **EM Signals & Chips, *no* Light** Telphykas

Comparison of Approaches

	Performance	Weight, Volume	Cost
Radio (no attitude)	*high*	*medium*	*high*
Analogue Inertial	*very high*	*high*	*very high*
Digital Inertial	*very high*	*very low*	*very low*

	Very low	*low*	*medium*	*high*	*very high*
ratio	1	3	10	30	100

9 **Cost, Volume & Weight Down; Precision Up** Telphykas

Some Selling Points

- fully digital
  - fully solid-state
- extremely reliable
  - lowest power consumption
- covering all requirements
  - fully cost competitive
- operational in any environment
  - building block system
- easy system back-up by doubling/tripling
  - simple to operate
- no shadowing

10 **Affordable DPIP Anytime & Everywhere** Telphykas

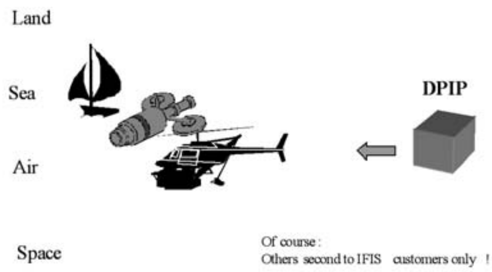
Time Scale & Status

2006	New Michelson (mobile)
2007	Digital Inertial Velocimeter & Rate Sensor
2008	Prototype Digital Precision Inertial Positioner **DPIP**
2009	First Product
2010	Product Family

Some Problems: - Frequency Stability
- Calibration
- Performance Variations
- Clock Standard
- Perfect Software
- Temperature Stability

11 **Two IFIS Periods** Telphykas

Conclusions



Of course :
Others second to IFIS customers only !

12 **DPIP for Everybody** Telphykas