TEKST NR 160 1988

Loop Groups and Instantons in Dimension Two

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TEKSTER fra

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IMFUFA tekst no.160/May 1, 1988 7 pages ISSN 0106-6242

Abstract. Radial trivialization from the poles gives a map from the space of equivalence classes of connections in a G-bundle over S^2 to the space of loops ΩG. The map is a homotopy equivalence, and if the equivalence class $[\omega]$ is mapped to the loop γ, then γ together with a map $f\colon S^2 \to \mathfrak{g}$ into the Lie algebra give a complete description of $[\omega]$. The Yang-Mills functional taken at $[\omega]$ corresponds to the sum of the energy of γ and a certain norm of f. In particular, the moduli space of instantons is the same as the space of homomorphisms $S^1 \to G$.

There is a similar description of connections in a G-bundle over an arbitrary Riemann surface, but so far not of the Yang-Mills functional and the moduli space.

Keywords. Loop groups, Yang-Mills equations, Riemann surfaces.
1980 *Mathematics subject classifications*: 32G13

1. Instantons on the Sphere

Consider the two dimensional unit sphere

$$S^2 = \{(x, y, z) \in \mathbf{R}^3 \mid x^2 + y^2 + z^2 = 1\}.$$

Denote $(0, 0, 1)$ by ∞ (the North Pole), (0,0,-1) by 0 (the South Pole), the complement of 0 by U_∞, the complement of ∞ by U_0, the part of S^2 where $z > 0$ by D_∞ (the northern hemisphere) and the part of S^2 where $z < 0$ by D_0 (the southern hemisphere). Finally let $\varphi \in [0, \pi]$ and $\theta \in [0, 2\pi]$ be spherical coordinates on S^2.

Let G be a compact Lie group with Lie algebra $\mathfrak{g}$ and let P be a principal G-bundle over S^2 with a connection ω. Choose a base point p_∞ in the fiber over ∞.

By lifting the curves $t \mapsto (t, \theta)$ for $\theta \in [0, 2\pi]$ to horizontal curves in P starting at p_∞, we get a section σ_∞ in P over U_∞, and by lifting the curves $t \mapsto (\pi - t, \theta)$ to horizontal curves in P starting at some point p_0 in the fiber over 0, we get a section σ_0 in P over U_0. We say that σ_0 and σ_∞ are obtained by *radial trivialization* from the poles. Henceforth j denotes either 0 or ∞.

(1.1) LEMMA. *The sections σ_0 and σ_∞ in P are smooth.*

PROOF: Use the connection on P to combine the metric on S^2 and the biinvariant metric on G to give a metric on P. Obviously a horizontal lift of a geodesic in S^2 gives a geodesic in P. Hence $\sigma_j = \exp_P \circ \pi_*^{-1} \circ \exp_{S^2}^{-1}$, where π_* is the projection from the horizontal space in P to TS^2 and $\exp_M$ is the exponential map from TM to M. □

The transition function $\gamma\colon U_0 \cap U_\infty \to G$ is defined by

$$\sigma_0 = \sigma_\infty \gamma. \tag{1.2}$$

As the curve $t \mapsto \sigma_j(t, \theta)$ is horizontal, $t \mapsto \gamma(t, \theta)$ is constant for all θ, hence γ can be regarded as a smooth map $\gamma\colon S^1 \to G$, i.e. as an element of LG.

As p_0 is arbitrary, σ_0 and hence γ is only determined up to multiplication by an element of G, but we have a well-defined element of $LG/G = \Omega G$. Alternatively we can put $p_0 = \lim_{t \to \pi} \sigma_\infty(t, 0)$.

We put

$$\omega_j = \sigma_j^*(\omega) \in \Omega^1 \left(E_{\mathfrak{g}}|_{U_j}\right) \cong C^\infty \left(\bigwedge\nolimits^1 (U_j, \mathfrak{g})\right) \tag{1.3}$$

where $E_{\mathfrak{g}} = P \times_G \mathfrak{g}$.

(1.4) LEMMA. *The loop γ and the forms ω_0, ω_∞ are gauge invariant.*

PROOF: Let g be a based gauge transformation, i.e. an automorphism $g\colon P \to P$ with $g(p_\infty) = p_\infty$. Then $\widetilde{\sigma}_j = g^{-1} \circ \sigma_j$ is the section induced by the gauge transformed connection $\widetilde{\omega} = g^*(\omega)$. We can write $\widetilde{\sigma}_j = \sigma_j g_j$, then $g_0 = \gamma^{-1} g_\infty \gamma$,

$$\widetilde{\sigma}_0 = \sigma_0 g_0 = (\sigma_\infty \gamma)(\gamma^{-1} g_\infty \gamma) = \sigma_\infty g_\infty \gamma = \widetilde{\sigma}_\infty \gamma$$

and

$$\widetilde{\omega}_j = \widetilde{\sigma}_j^*(\widetilde{\omega}) = (g^{-1} \circ \sigma_j)^*(g^*(\omega)) = \sigma_j^* {g^{-1}}^* g^*(\omega) = \sigma_j^*(\omega) = \omega_j. \quad \square$$

The curve $t \mapsto \sigma_j(t,\theta)$ is horizontal, hence $\omega_0(0) = \omega_\infty(\infty) = 0$ and $\omega_j = f_j d\theta$. As $f_0 = \gamma^{-1} f_\infty \gamma + \gamma^{-1}\gamma'$, we can put

$$f = f_0 - \cos^2\left(\frac{\varphi}{2}\right)\gamma^{-1}\gamma' = \gamma^{-1}\left(f_\infty + \sin^2\left(\frac{\varphi}{2}\right)\gamma'\gamma^{-1}\right)\gamma, \tag{1.5}$$

and obtain a well-defined map $f\colon S^2 \to \mathfrak{g}$.

As ω_0 has zero $d\phi$ component, $[\omega_0, \omega_0] = 0$, so the curvature R^ω has on U_0 the local expression

$$R_0^\omega = d\omega_0 = \frac{\partial f_0}{\partial \varphi}\, d\varphi \wedge d\theta$$

and

$$\frac{\partial f_0}{\partial \varphi} = \frac{\partial f}{\partial \varphi} - \cos\left(\frac{\varphi}{2}\right)\sin\left(\frac{\varphi}{2}\right)\gamma^{-1}\gamma' = \frac{\partial f}{\partial \varphi} - \frac{1}{2}\sin(\varphi)\gamma^{-1}\gamma'.$$

The Yang-Mills functional of the connection ω is given by

$$\mathcal{YM}(\omega) = \frac{1}{2}\int_{S^2} \|R^\omega\|^2 = \frac{1}{2}\int_{S^2} \langle *R^\omega, *R^\omega\rangle \, d\Omega,$$

where $*$ is the Hodge star operator, $d\Omega = \sin(\varphi)\, d\varphi \wedge d\theta$ is the standard volume form on S^2 and the bracket is the inner product on the Lie algebra $\mathfrak{g}$. We have $*(d\varphi \wedge d\theta) = \frac{1}{\sin(\varphi)}$, so

$$\begin{aligned}
\mathcal{YM}(\omega) &= \frac{1}{2}\int_0^{2\pi}\!\!\int_0^\pi \left\|\frac{\partial f_0}{\partial \varphi}\frac{1}{\sin(\varphi)}\right\|^2 \sin(\varphi)\, d\varphi\, d\theta \\
&= \frac{1}{2}\int_0^{2\pi}\!\!\int_0^\pi \left\langle \frac{\partial f}{\partial \varphi} - \frac{1}{2}\sin(\varphi)\gamma^{-1}\gamma', \frac{\partial f}{\partial \varphi} - \frac{1}{2}\sin(\varphi)\gamma^{-1}\gamma' \right\rangle \frac{1}{\sin(\varphi)}\, d\varphi\, d\theta \\
&= \frac{1}{2}\int_0^{2\pi}\!\!\int_0^\pi \left\|\frac{1}{\sin(\varphi)}\frac{\partial f}{\partial \varphi}\right\|^2 \sin(\varphi)\, d\varphi\, d\theta \\
&\quad - \frac{1}{2}\int_0^{2\pi}\!\!\int_0^\pi \left\langle \frac{\partial f}{\partial \varphi}, \gamma^{-1}\gamma' \right\rangle d\varphi\, d\theta \\
&\quad + \frac{1}{8}\int_0^{2\pi}\!\!\int_0^\pi \|\gamma'\gamma^{-1}\|^2 \sin(\varphi)\, d\varphi\, d\theta.
\end{aligned}$$

We have

$$\int_0^{2\pi}\!\!\int_0^\pi \left\langle \frac{\partial f}{\partial \varphi}, \gamma^{-1}\gamma' \right\rangle d\varphi\, d\theta = \int_0^{2\pi} \left[\langle f, \gamma^{-1}\gamma'\rangle\right]_0^\pi d\theta = 0$$

and

$$\int_0^{2\pi}\int_0^{\pi} \left\|\gamma^{-1}\gamma'\right\|^2 \sin(\varphi)\, d\varphi\, d\theta = \int_0^{\pi} \sin(\varphi)\, d\varphi \int_0^{2\pi} \left\|\gamma^{-1}\gamma'\right\|^2\, d\theta$$
$$= 2\int_0^{2\pi} \left\|\gamma^{-1}\gamma'\right\|^2\, d\theta$$
$$= 8\pi\mathcal{E}(\gamma),$$

where $\mathcal{E}(\gamma)$ is the *energy* of the loop γ. Finally $\int_0^{2\pi}\int_0^{\pi}\left\|\frac{1}{\sin(\varphi)}\frac{\partial f}{\partial\varphi}\right\|^2 \sin(\varphi)\, d\varphi\, d\theta$ is a norm $\|\cdot\|$ on the vector space $\{f \in C^\infty(S^2, \mathfrak{g}) \mid f(0) = f(\infty) = 0\}$. If we let $\mathcal{H}$ be the completion, then we have proved

(1.6) THEOREM. *Let $\mathcal{C}$ be the space of connections, $\mathcal{G}_0$ the group of based gauge transformations and $\mathcal{B} = \mathcal{C}/\mathcal{G}_0$ the orbit space, then the map $\omega \mapsto (\gamma, f)$ induces an injection*

$$\mathcal{B} \hookrightarrow \Omega G \times \mathcal{H}$$

and

$$\mathcal{YM}(\omega) = \tfrac{1}{2}\|f\|^2 + \pi\mathcal{E}(\gamma).$$

The image of $\mathcal{B}$ is not a product of ΩG and a subspace of $\mathcal{H}$, but consists of pairs (γ, f) such that f_0 and f_∞ defined by (1,5) are smooth on U_0 and U_∞ respectively. Especially, f is smooth outside $\{0, \infty\}$.

We could replace (1.5) with

$$\widetilde{\omega} = \omega_0 - h(\varphi)\gamma^{-1}\gamma'\, d\theta = \gamma^{-1}\left(\omega_\infty + h(\varphi)\gamma'\gamma^{-1}\right)\gamma, \tag{1.7}$$

where $h(\varphi)$ is a smooth function, which is 0 in a neighbourhood of π and 1 in a neighbourhood of 0. Then $\widetilde{\omega}$ is a smooth one form on S^2 with values in $\mathfrak{g}$ and with $\widetilde{\omega}(\frac{\partial}{\partial\varphi}) = 0$ at all points. Conversely, given $\gamma \in \Omega G$ and such a one form $\widetilde{\omega}$, then (1.7) gives a pair ω_0, ω_∞, which in turn defines a connection in the bundle defined by γ. I.e. we have

(1.8) THEOREM. *The map $\mathcal{B} \to \Omega G$ is a trivial vector bundle.*

But we do not have the nice formula for the Yang-Mills functional, because if we try to use (1.7) in the calculation, then the mixed term $\int\langle d\widetilde{\omega}, h'\gamma^{-1}\gamma'\rangle$ does not vanish.

2. Holomorphic trivialization

If $G_\mathbf{C}$ is the complexification of G and $LG_\mathbf{C}$ is the space of free smooth loops in $G_\mathbf{C}$, then $\Omega G = LG_\mathbf{C}/L^+G_\mathbf{C}$, where $L^+G_\mathbf{C}$ is the space of loops which is the boundary value of a holomorphic map $D \to G_{\mathbb{C}}$ and D is the unit disk in $\mathbb{C}$, see [**2**]. We can use this description of ΩG to get a different map $\mathcal{C} \to \Omega G$.

Using stereographic projection, we identify S^2 with $\mathbb{C} \cup \{\infty\}$. Then U_0 corresponds to $\mathbb{C}$, D_0 corresponds to the unit disk, and the meaning of 0 and ∞ are unchanged.

The connection ω on P induces a holomorphic structure on the complexified bundle $P_{\mathbb{C}} = P \times_G G_{\mathbb{C}}$, see [**1**], and the base point p_∞ in P is also a base point in $P_{\mathbb{C}}$. We still let σ_∞ be obtained by radial trivialization from the North Pole, but now σ_0 shall be a holomorphic section over $\overline{D}_0$ (it means that σ_0 is smooth on $\overline{D}$ and holomorphic on D_0). As before $\gamma \in LG_{\mathbb{C}}$ is defined by $\sigma_0 = \sigma_\infty \gamma$, and clearly γ is well-defined up to multiplication with an element of $L^+G_{\mathbb{C}}$, i.e. we have a well-defined element $[\gamma] \in LG_{\mathbb{C}}/L^+G_{\mathbb{C}} = \Omega G$.

Let $\widehat{\sigma}_0$ denote the section over D_0 and $\widehat{\gamma}$ the loop in G obtained by radial trivialization. We want to find a holomorphic section of $P_{\mathbb{C}}$ over D_0. Such a section has the form $\widehat{\sigma}_0 g$, where $g \colon \overline{D}_0 \to G_{\mathbb{C}}$, and then $\gamma = \widehat{\gamma} g$.

In the trivialization defined by the section $\widehat{\sigma}_0$, the covariant derivative induced by ω is $\nabla = d + f_0\, d\theta$. We have $z = \cot(\frac{\varphi}{2})e^{i\theta}$, so

$$dz = d\left(\cot\left(\tfrac{\varphi}{2}\right)\right)e^{i\theta} + \cot\left(\tfrac{\varphi}{2}\right) ie^{i\theta} d\theta,$$

and

$$d\theta = \frac{i}{2\cot\left(\frac{\varphi}{2}\right)}\left(e^{i\theta}\, d\overline{z} - e^{-i\theta}\, dz\right) = \frac{i}{2|z|^2}(z\, d\overline{z} - \overline{z}\, dz).$$

If $g \colon \overline{D}_0 \to G_{\mathbb{C}}$, then $\sigma_0 g \colon \overline{D}_0 \to P_{\mathbb{C}}$ is holomorphic if and only if

$$(*) \qquad g^{-1}\frac{\partial g}{\partial \overline{z}} + \frac{iz}{2|z|^2} g^{-1} f_0 g = 0.$$

In general we have $[\gamma] \neq [\widehat{\gamma}]$ because equality holds if and only if $g|_{S^1} \in L^+G_{\mathbb{C}}$ and this need not be the case. Choose for example $\gamma = 1$ and $f(z) = 4i|z|^2\overline{z}A$ on D_0 with $A \in \mathfrak{g}$, then $(*)$ becomes

$$g^{-1}\frac{\partial g}{\partial \overline{z}} - 2z\overline{z}g^{-1}Ag = 0.$$

A solution is $g(z) = \exp(z\overline{z}^2 A)$, but $g(e^{i\theta}) = \exp(e^{-i\theta}A)$ so $g|_{S^1} \notin L^+G_{\mathbb{C}}$.

But, if ω is an instanton, then $f = 0$ and $\gamma = \exp(\theta A)$ for some $A \in \mathfrak{g}$, hence

$$f_0 = f + \cos^2\left(\frac{\varphi}{2}\right)\gamma^{-1}\gamma' = \frac{|z|^2}{1+|z|^2}A.$$

So $(*)$ becomes

$$g^{-1}\frac{\partial g}{\partial \overline{z}} + \frac{i}{2}\frac{z}{1+|z|^2} g^{-1} A g = 0,$$

and $g(z) = \exp(-\frac{i}{2}\log(1+|z|^2)A)$ is a solution. As $g(e^{i\theta}) = \exp\left(-\frac{i\log 2}{2}A\right)$, $g \in L^+G_{\mathbb{C}}$ and $[\gamma] = [\widehat{\gamma} g] = [\widehat{\gamma}]$.

3. The General Case

The process described in §2 makes sense on any closed Riemann surface X. Choose a point x_∞ on X and a local parameter around x_∞. We shall write the local parameter as z^{-1}, thus z is a holomorphic map from a neighbourhood of x_∞ to a neighbourhood of ∞ in the Riemann sphere. We may assume that $z(x_\infty) = \infty$, and that z is an isomorphism between a neighbourhood U_∞ of x_∞ and the region $|z| > \frac{1}{2}$ on the Riemann sphere. The standard circle S^1 can then be identified with the circle $|z| = 1$ around x_∞ on X. We denote the part of X where $|z| > 1$ by X_∞, and the complement of the region where $|z| \geq 1$ by X_0. Thus

$$\overline{X}_0 \cap \overline{X}_\infty = S^1.$$

The space of smooth loops $\gamma\colon S^1 \to G_{\mathbf{C}}$, which is the boundary value of a holomorphic map $X_0 \to G_{\mathbf{C}}$, is denoted $L^+_X G_{\mathbf{C}}$. Both $\Omega G = LG_{\mathbf{C}}/L^+G_{\mathbf{C}}$ and the quotient $Gr^X = LG_{\mathbf{C}}/L^+_X G_{\mathbf{C}}$ are subvarieties of an infinite dimensional Grassmannian Gr, see **[2]**.

Let P be a principal G-bundle over X with a connection ω and choose a base point p_∞ in the fiber over x_∞. Let $\theta \in [0, 2\pi]$ and $r \in (\frac{1}{2}, \infty]$ be polar coordinates on U_∞ and lift the curves $t \mapsto (\frac{1}{t}, \theta)$, with $t \in [0,1]$ and $\theta \in [0, 2\pi]$, to horizontal curves in P starting at p_∞. As for S^2, we get a smooth section σ_∞ in P over $\overline{X}_\infty$.

Let σ_0 be a holomorphic section in the complexified bundle $P_{\mathbf{C}}$ over $\overline{X}_0$. The transition function $\gamma\colon S^1 \to G_{\mathbf{C}}$ is defined by

$$\sigma_0|_{S^1} = \sigma_\infty|_{S^1}\, \gamma. \tag{3.1}$$

As the section σ_0 is only determined up to multiplication by a holomorphic map $\overline{X}_0 \to G_{\mathbf{C}}$, the loop γ is only determined up to multiplication by an element of $L^+_X G_{\mathbf{C}}$, but we have a well-defined element $[\gamma] \in LG_{\mathbf{C}}/L^+_X G_{\mathbf{C}} = Gr^X$. We put

$$\omega_j = \sigma_j^*(\omega)$$

Not any triple $(\gamma, \omega_0, \omega_\infty)$ can be obtained this way. At least we must have $\omega_0 \in C^\infty\left(\bigwedge^{1,0}(\overline{X}_0, \mathfrak{g}_{\mathbf{C}})\right)$ and $\omega_\infty = f_\infty\, d\theta$ with $f_\infty\colon \overline{X}_\infty \to \mathfrak{g}$. Given such a triple let us try to construct a G-bundle with a connection.

Using the connection ω_0 on $\overline{X}_0 \times G_{\mathbf{C}}$, we extend γ by radial trivialization from S^1 and obtain a smooth map $\widetilde{\gamma}\colon \overline{X}_0 \cap U_\infty \to G_{\mathbf{C}}$, which satisfies

$$\widetilde{\gamma}^{-1}\frac{\partial \widetilde{\gamma}}{\partial r} = \omega_0\left(\frac{\partial}{\partial r}\right) \qquad \text{and} \qquad \widetilde{\gamma}|_{S^1} = \gamma. \tag{3.2}$$

We can now use $\widetilde{\gamma}$ as the transition function in a smooth $G_{\mathbf{C}}$-bundle $P_{\mathbf{C}}$. Next we must extend ω_∞ to a one form $\widetilde{\omega}_\infty = \widetilde{f}_\infty\, d\theta$ with $\widetilde{f}_\infty\colon U_\infty \to \mathfrak{g}$, such that

$$\omega_0 = \widetilde{\gamma}^{-1}\widetilde{\omega}_\infty\widetilde{\gamma} + \widetilde{\gamma}^{-1}\, d\widetilde{\gamma}.$$

In view of (3.2) this is equivalent to

$$\omega_0\left(\frac{\partial}{\partial\theta}\right)=\widetilde{\gamma}^{-1}\widetilde{\omega}_\infty\left(\frac{\partial}{\partial\theta}\right)\widetilde{\gamma}+\widetilde{\gamma}^{-1}\frac{\partial\widetilde{\gamma}}{\partial\theta},$$

or

$$\widetilde{f}_\infty=\widetilde{\omega}_\infty\left(\frac{\partial}{\partial\theta}\right)=\widetilde{\gamma}\omega_0\left(\frac{\partial}{\partial\theta}\right)\widetilde{\gamma}^{-1}+\frac{\partial\widetilde{\gamma}}{\partial\theta}\widetilde{\gamma}^{-1}.$$

We can get such an extension if and only if we at S^1 have that

$$f_\infty=\omega_\infty\left(\frac{\partial}{\partial\theta}\right)=\widetilde{\gamma}\omega_0\left(\frac{\partial}{\partial\theta}\right)\widetilde{\gamma}^{-1}+\frac{\partial\widetilde{\gamma}}{\partial\theta}\widetilde{\gamma}^{-1}\text{ to all orders.}\tag{3.3}$$

If (3.3) is satisfied, then we get a connection on $P_{\mathbf{C}}$. Finally, as ω_∞ has values in $\mathfrak{g}$ we have a G-structure over $\overline{X}_\infty$. And over $\overline{X}_0$ the complex structure together with the connection give a G-structure. So all in all we get a G-bundle with a connection.

Furthermore, given (γ,ω_0) such that the right-hand side of (3.3) lies in $\mathfrak{g}$ at S^1, then by [**3**] we can find ω_∞ satisfying (3.3), and ω_∞ can be chosen such that it depends continuously on (γ,ω_0). Let

$$\Omega^1_{d\theta}(\overline{X}_\infty,\mathfrak{g})=\left\{\alpha\in\Omega^1(\overline{X}_\infty,\mathfrak{g})\,\middle|\,\alpha\left(\tfrac{\partial}{\partial r}\right)=0\right\},$$

$$\mathcal{K}=\left\{(\gamma,\omega_0,\omega_\infty)\in LG_{\mathbf{C}}\times\Omega^{1,0}\left(\overline{X}_0,\mathfrak{g}_{\mathbf{C}}\right)\times\Omega^1_{d\theta}\left(\overline{X}_\infty,\mathfrak{g}\right)\mid(3.3)\text{ is satiesfied}\right\}$$

and

$$\mathcal{L}=\left\{(\gamma,\omega_0)\in LG_{\mathbf{C}}\times\Omega^{1,0}\left(\overline{X}_0,\mathfrak{g}_{\mathbf{C}}\right)\,\middle|\,\widetilde{\gamma}\omega_0\left(\frac{\partial}{\partial\theta}\right)\widetilde{\gamma}^{-1}+\frac{\partial\widetilde{\gamma}}{\partial\theta}\widetilde{\gamma}^{-1}\in\mathfrak{g}\text{ on }S^1\right\}.$$

We let $\mathcal{C}$ denote the space of connections, $\mathcal{G}_0$ the group of based gauge transformations and $\mathcal{B}$ the orbit space $\mathcal{C}/\mathcal{G}_0$.

The group $L^+_XG_{\mathbf{C}}$ acts on $\mathcal{L}$ (and $\mathcal{K}$) by $(\gamma,\omega_0)g=(\gamma g,g^{-1}\omega_0g+g^{-1}\,dg)$, and we have well defined maps

$$\begin{array}{ccc}\mathcal{B}&\xrightarrow{\cong}&\mathcal{K}/L^+_XG_{\mathbf{C}}\\&&\downarrow\\&&\mathcal{L}/L^+_XG_{\mathbf{C}}\\&&\downarrow\\&&Gr^X.\end{array}$$

The map $\mathcal{K}/L^+_XG_{\mathbf{C}}\to\mathcal{L}/L^+_XG_{\mathbf{C}}$ is an affine bundle, and the vector space of translations is in each fiber

$$\left\{\omega_\infty\in\Omega^1_{d\theta}(\overline{X}_\infty,\mathfrak{g})\mid\omega_\infty\text{ vanishes to all orders on }S^1\right\}.$$

Likewise $\mathcal{L}/L^+_XG_{\mathbf{C}}\to Gr^X$ is an affine bundle with fiber

$$\left\{\omega_0\in\Omega^{1,0}(\overline{X}_0,\mathfrak{g}_{\mathbf{C}})\mid\omega_0\in\gamma^{-1}\mathfrak{g}\gamma-\gamma^{-1}\gamma'\text{ on }S^1\right\}.$$

Hence we have

(3.4) THEOREM. *The map $\mathcal{B} \to Gr^X$ is a homotopy equivalence.*

It is already known that $\mathrm{Map}(X, BG)$ is homotopy equivalent to both $\mathcal{B}$, see [**1**], and Gr^X, see [**2**]. We have now shown the third homotopy equivalence directly.

It would be nice if one could get a theorem like (1.6) for a general Riemann surface. In §2 we saw that the map we get by radial trivialization is different from the map given by holomorphic trivialization, so perhaps theorem (1.6) is too much to ask for. But the two maps agree on on the moduli space of instantons, so we could look for a function $\mathcal{F}\colon Gr^X \to \mathbf{R}$, such that the moduli space of instantons is mapped bijectively to the critical points of $\mathcal{F}$.

The energy-function on ΩG is the restriction of a function defined on all of Gr, see [**2**], so the restriction to Gr^X could be a candidate for $\mathcal{F}$.

References

1. M. F. Atiyah & R. Bott, *The Yang-Mills Equations over Riemann Surfaces*, Phil. Trans. R. Soc. Lond. **A 308** (1982), 523–615.
2. A. Pressley & G. Segal, "Loop Groups," Clarendon Press, Oxford, 1986.
3. R. T. Seeley, *Extentions of C^∞-Functions Defined in a Half Space*, Proc. Amer. Math. Soc **15** (1964), 625–626.

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Projektrapport af: Jan Christensen og Knud Lindhardt Rasmussen.
Vejleder: Mogens Niss.

25/80 "EKSAMENSOPGAVER", Dybdemodulet/fysik 1974-79.

26/80 "OM MATEMATISKE MODELLER".
En projektrapport og to artikler.
Af: Jens Højgaard Jensen m.fl.

27/80 "METHODOLOGY AND PHILOSOPHY AF SCIENCE IN PAUL DIRAC's PHYSICS".
Af: Helge Kragh.

28/80 "DIELEKTRISK RELAXATION - et forslag til en ny model bygget på væskernes viscoelastiske egenskaber".
Projektrapport af: Gert Kreinøe.
Vejleder: Niels Boye Olsen.

29/80 "ODIN - undervisningsmateriale til et kursus i differentialligningsmodeller".
Projektrapport af: Tommy R. Andersen, Per H.H. Larsen og Peter H. Lassen.
Vejleder: Mogens Brun Heefelt.

30/80 "FUSIONSENERGIEN - - - ATOMSAMFUNDETS ENDESTATION".
Af: Oluf Danielsen.
Nr. 30 er udgået.

31/80 "VIDENSKABSTEORETISKE PROBLEMER VED UNDERVISNINGSSYSTEMER BASERET PÅ MÆNGDELÆRE".
Projektrapport af: Troels Lange og Jørgen Karrebæk.
Vejleder: Stig Andur Pedersen.
Nr. 31 er p.t. udgået.

32/80 "POLYMERE STOFFERS VISCOELASTISKE EGENSKABER - BELYST VED HJÆLP AF MEKANISKE IMPEDANSMÅLINGER MÖSSBAUEREFFEKTMÅLINGER".
Projektrapport af: Crilles Bacher og Preben Jensen.
Vejledere: Niels Boye Olsen og Peder Voetmann Christiansen.

33/80 "KONSTITUERING AF FAG INDEN FOR TEKNISK - NATURVIDENSKABELIGE UDDANNELSER. I-II".
Af: Arne Jakobsen.

34/80 "ENVIRONMENTAL IMPACT AF WIND ENERGY UTILIZATION".
ENERGY SERIES NO. I.
Af: Bent Sørensen
Nr. 34 er udgået.

35/80 "HISTORISKE STUDIER I DEN NYERE ATOMFYSIKS UDVIKLING".
Af: Helge Kragh.

36/80 "HVAD ER MENINGEN MED MATEMATIKUNDERVISNINGEN?".
Fire artikler.
Af: Mogens Niss.

37/80 "RENEWABLE ENERGY AND ENERGY STORAGE".
ENERGY SERIES NO. 2.
Af: Bent Sørensen.

38/81 "TIL EN HISTORIETEORI OM NATURERKENDELSE, TEKNOLOGI OG SAMFUND".
Projektrapport af: Erik Gade, Hans Hedal, Henrik Lau og Finn Physant.
Vejledere: Stig Andur Pedersen, Helge Kragh og Ib Thiersen.
Nr. 38 er p.t. udgået.

39/81 "TIL KRITIKKEN AF VÆKSTØKONOMIEN".
Af: Jens Højgaard Jensen.

40/81 "TELEKOMMUNIKATION I DANMARK - oplæg til en teknologivurdering".
Projektrapport af: Arne Jørgensen, Bruno Petersen og Jan Vedde.
Vejleder: Per Nørgaard.

41/81 "PLANNING AND POLICY CONSIDERATIONS RELATED TO THE INTRODUCTION OF RENEWABLE ENERGY SOURCES INTO ENERGY SUPPLY SYSTEMS".
ENERGY SERIES NO. 3.
Af: Bent Sørensen.

42/81 "VIDENSKAB TEORI SAMFUND - En introduktion til materialistiske videnskabsopfattelser".
Af: Helge Kragh og Stig Andur Pedersen.

43/81 1."COMPARATIVE RISK ASSESSMENT OF TOTAL ENERGY SYSTEMS".
2."ADVANTAGES AND DISADVANTAGES OF DECENTRALIZATION".
ENERGY SERIES NO. 4.
Af: Bent Sørensen.

44/81 "HISTORISKE UNDERSØGELSER AF DE EKSPERIMENTELLE FORUDSÆTNINGER FOR RUTHERFORDS ATOMMODEL".
Projektrapport af: Niels Thor Nielsen.
Vejleder: Bent C. Jørgensen.

45/82 Er aldrig udkommet.

46/82 "EKSEMPLARISK UNDERVISNING OG FYSISK ERKENDESE-
1+11 ILLUSTRERET VED TO EKSEMPLER".
Projektrapport af: Torben O.Olsen, Lasse Rasmussen og Niels Dreyer Sørensen.
Vejleder: Bent C. Jørgensen.

47/82 "BARSEBÄCK OG DET VÆRST OFFICIELT-TÆNKELIGE UHELD".
ENERGY SERIES NO. 5.
Af: Bent Sørensen.

48/82 "EN UNDERSØGELSE AF MATEMATIKUNDERVISNINGEN PÅ ADGANGSKURSUS TIL KØBENHAVNS TEKNIKUM".
Projektrapport af: Lis Eilertzen, Jørgen Karrebæk, Troels Lange, Preben Nørregaard, Lissi Pedesen, Laust Rishøj, Lill Røn og Isac Showiki.
Vejleder: Mogens Niss.

49/82 "ANALYSE AF MULTISPEKTRALE SATELLITBILLEDER".
Projektrapport af: Preben Nørregaard.
Vejledere: Jørgen Larsen og Rasmus Ole Rasmussen.

50/82 "HERSLEV - MULIGHEDER FOR VEDVARENDE ENERGI I EN LANDSBY".
ENERGY SERIES NO. 6.
Rapport af: Bent Christensen, Bent Hove Jensen, Dennis B. Møller, Bjarne Laursen, Bjarne Lillethorup og Jacob Mørch Pedersen.
Vejleder: Bent Sørensen.

51/82 "HVAD KAN DER GØRES FOR AT AFHJÆLPE PIGERS BLOKERING OVERFOR MATEMATIK ?"
Projektrapport af: Lis Eilertzen, Lissi Pedersen, Lill Røn og Susanne Stender.

52/82 "DESUSPENSION OF SPLITTING ELLIPTIC SYMBOLS".
Af: Bernhelm Booss og Krzysztof Wojciechowski.

53/82 "THE CONSTITUTION OF SUBJECTS IN ENGINEERING EDUCATION".
Af: Arne Jacobsen og Stig Andur Pedersen.

54/82 "FUTURES RESEARCH" - A Philosophical Analysis of Its Subject-Matter and Methods.
Af: Stig Andur Pedersen og Johannes Witt-Hansen.

55/82 "MATEMATISKE MODELLER" - Litteratur på Roskilde Universitetsbibliotek.
En biografi.
Af: Else Høyrup.

Vedr. tekst nr. 55/82 se også tekst nr. 62/83.

56/82 "EN - TO - MANGE" -
En undersøgelse af matematisk økologi.
Projektrapport af: Troels Lange.
Vejleder: Anders Madsen.

57/83 "ASPECT EKSPERIMENTET"-
Skjulte variable i kvantemekanikken?
Projektrapport af: Tom Juul Andersen.
Vejleder: Peder Voetmann Christiansen.
Nr. 57 er udgået.

58/83 "MATEMATISKE VANDRINGER" - Modelbetragtninger over spredning af dyr mellem småbiotoper i agerlandet.
Projektrapport af: Per Hammershøj Jensen og Lene Vagn Rasmussen.
Vejleder: Jørgen Larsen.

59/83 "THE METHODOLOGY OF ENERGY PLANNING".
ENERGY SERIES NO. 7.
Af: Bent Sørensen.

60/83 "MATEMATISK MODEKSPERTISE"- et eksempel.
Projektrapport af: Erik O. Gade, Jørgen Karrebæk og Preben Nørregaard.
Vejleder: Anders Madsen.

61/83 "FYSIKS IDEOLOGISKE FUNKTION, SOM ET EKSEMPEL PÅ EN NATURVIDENSKAB - HISTORISK SET".
Projektrapport af: Annette Post Nielsen.
Vejledere: Jens Høyrup, Jens Højgaard Jensen og Jørgen Vogelius.

62/83 "MATEMATISKE MODELLER" - Litteratur på Roskilde Universitetsbibliotek.
En biografi 2. rev. udgave.
Af: Else Høyrup.

63/83 "GREATING ENERGY FUTURES:A SHORT GUIDE TO ENERGY PLANNING".
ENERGY SERIES No. 8.
Af: David Crossley og Bent Sørensen.

64/83 "VON MATEMATIK UND KRIEG".
Af: Berhelm Booss og Jens Høyrup.

65/83 "ANVENDT MATEMATIK - TEORI ELLER PRAKSIS".
Projektrapport af: Per Hedegård Andersen, Kirsten Habekost, Carsten Holst-Jensen, Annelise von Moos, Else Marie Pedersen og Erling Møller Pedersen.
Vejledere: Bernhelm Booss og Klaus Grünbaum.

66/83 "MATEMATISKE MODELLER FOR PERIODISK SELEKTION I ESCHERICHIA COLI".
Projektrapport af: Hanne Lisbet Andersen, Ole Richard Jensen og Klavs Frisdahl.
Vejledere: Jørgen Larsen og Anders Hede Madsen.

67/83 "ELEPSOIDE METODEN - EN NY METODE TIL LINEÆR PROGRAMMERING?"
Projektrapport af: Lone Billmann og Lars Boye.
Vejleder: Mogens Brun Heefelt.

68/83 "STOKASTISKE MODELLER I POPULATIONSGENETIK"
- til kritikken af teoriladede modeller.
Projektrapport af: Lise Odgård Gade, Susanne Hansen, Michael Hviid og Frank Mølgård Olsen.
Vejleder: Jørgen Larsen.

69/83 "ELEVFORUDSÆTNINGER I FYSIK"
- en test i 1.g med kommentarer.
Af: Albert C. Paulsen.

70/83 "INDLÆRINGS - OG FORMIDLINGSPROBLEMER I MATEMATIK PÅ VOKSENUNDERVISNINGSNIVEAU".
Projektrapport af: Hanne Lisbet Andersen, Torben J. Andreasen, Svend Åge Houmann, Helle Glerup Jensen, Keld Fl. Nielsen, Lene Vagn Rasmussen.
Vejleder: Klaus Grünbaum og Anders Hede Madsen.

71/83 "PIGER OG FYSIK"
- et problem og en udfordring for skolen?
Af: Karin Beyer, Sussanne Blegaa, Birthe Olsen, Jette Reich og Mette Vedelsby.

72/83 "VERDEN IFØLGE PEIRCE" - to metafysiske essays, om og af C.S Peirce.
Af: Peder Voetmann Christiansen.

73/83 ""EN ENERGIANALYSE AF LANDBRUG"
- økologisk contra traditionelt.
ENERGY SERIES NO. 9
Specialeopgave i fysik af: Bent Hove Jensen.
Vejleder: Bent Sørensen.

74/84 "MINIATURISERING AF MIKROELEKTRONIK" - om videnskabeliggjort teknologi og nytten af at lære fysik.
Projektrapport af: Bodil Harder og Linda Szkotak Jensen.
Vejledere: Jens Højgaard Jensen og Bent C. Jørgensen.

75/84 "MATEMATIKUNDERVISNINGEN I FREMTIDENS GYMNASIUM"
- Case: Lineær programmering.
Projektrapport af: Morten Blomhøj, Klavs Frisdahl og Frank Mølgaard Olsen.
Vejledere: Mogens Brun Heefelt og Jens Bjørneboe.

76/84 "KERNEKRAFT I DANMARK?" - Et høringssvar indkaldt af miljøministeriet, med kritik af miljøstyrelsens rapporter af 15. marts 1984.
ENERGY SERIES No. 10
Af: Niels Boye Olsen og Bent Sørensen.

77/84 "POLITISKE INDEKS - FUP ELLER FAKTA?"
Opinionsundersøgelser belyst ved statistiske modeller.
Projektrapport af: Svend Åge Houmann, Keld Nielsen og Susanne Stender.
Vejledere: Jørgen Larsen og Jens Bjørneboe.

78/84 "JÆVNSTRØMSLEDNINGSEVNE OG GITTERSTRUKTUT I AMORFT GERMANIUM".
Specialrapport af: Hans Hedal, Frank C. Ludvigsen og Finn C. Physant.
Vejleder: Niels Boye Olsen.

79/84 "MATEMATIK OG ALMENDANNELSE".
Projektrapport af: Henrik Coster, Mikael Wennerberg Johansen, Povl Kattler, Birgitte Lydholm og Morten Overgaard Nielsen.
Vejleder: Bernhelm Booss.

80/84 "KURSUSMATERIALE TIL MATEMATIK B".
Af: Mogens Brun Heefelt.

81/84 "FREKVENSAFHÆNGIG LEDNINGSEVNE I AMORFT GERMANIUM".
Specialerapport af: Jørgen Wind Petersen og Jan Christensen.
Vejleder: Niels Boye Olsen.

82/84 "MATEMATIK - OG FYSIKUNDERVISNINGEN I DET AUTOMATISEREDE SAMFUND".
Rapport fra et seminar afholdt i Hvidovre 25-27 april 1983.
Red.: Jens Højgaard Jensen, Bent C. Jørgensen og Mogens Niss.

83/84 "ON THE QUANTIFICATION OF SECURITY":
PEACE RESEARCH SERIES NO. 1
Af: Bent Sørensen
nr. 83 er p.t. udgået

84/84 "NOGLE ARTIKLER OM MATEMATIK, FYSIK OG ALMENDANNELSE".
Af: Jens Højgaard Jensen, Mogens Niss m. fl.

85/84 "CENTRIFUGALREGULATORER OG MATEMATIK".
Specialerapport af: Per Hedegård Andersen, Carsten Holst-Jensen, Else Marie Pedersen og Erling Møller Pedersen.
Vejleder: Stig Andur Pedersen.

86/84 "SECURITY IMPLICATIONS OF ALTERNATIVE DEFENSE OPTIONS FOR WESTERN EUROPE".
PEACE RESEARCH SERIES NO. 2
Af: Bent Sørensen.

87/84 "A SIMPLE MODEL OF AC HOPPING CONDUCTIVITY IN DISORDERED SOLIDS".
Af: Jeppe C. Dyre.

88/84 "RISE, FALL AND RESURRECTION OF INFINITESIMALS".
Af: Detlef Laugwitz.

89/84 "FJERNVARMEOPTIMERING".
Af: Bjarne Lillethorup og Jacob Mørch Pedersen.

90/84 "ENERGI I 1.G - EN TEORI FOR TILRETTELÆGGELSE".
Af: Albert Chr. Paulsen.

91/85 "KVANTETEORI FOR GYMNASIET".
1. Lærervejledning
Projektrapport af: Biger Lundgren, Henning Sten Hansen og John Johansson.
Vejleder: Torsten Meyer.

92/85 "KVANTETEORI FOR GYMNASIET".
2. Materiale
Projektrapport af: Biger Lundgren, Henning Sten Hansen og John Johansson.
Vejleder: Torsten Meyer.

93/85 "THE SEMIOTICS OF QUANTUM - NON - LOCALITY".
Af: Peder Voetmann Christiansen.

94/85 "TREENIGHEDEN BOURBAKI - generalen, matematikeren og ånden".
Projektrapport af: Morten Blomhøj, Klavs Frisdahl og Frank M. Olsen.
Vejleder: Mogens Niss.

95/85 "AN ALTERNATIV DEFENSE PLAN FOR WESTERN EUROPE".
PEACE RESEARCH SERIES NO. 3
Af: Bent Sørensen

96/85 "ASPEKTER VED KRAFTVARMEFORSYNING".
Af: Bjarne Lilletorup.
Vejleder: Bent Sørensen.

97/85 "ON THE PHYSICS OF A.C. HOPPING CONDUCTIVITY".
Af: Jeppe C. Dyre.

98/85 "VALGMULIGHEDER I INFORMATIONSALDEREN".
Af: Bent Sørensen.

99/85 "Der er langt fra Q til R".
Projektrapport af: Niels Jørgensen og Mikael Klintorp.
Vejleder: Stig Andur Pedersen.

100/85 "TALSYSTEMETS OPBYGNING".
Af: Mogens Niss.

101/85 "EXTENDED MOMENTUM THEORY FOR WINDMILLS IN PERTURBATIVE FORM".
Af: Ganesh Sengupta.

102/85 OPSTILLING OG ANALYSE AF MATEMATISKE MODELLER, BELYST VED MODELLER OVER KØERS FODEROPTAGELSE OG - OMSÆTNING".
Projektrapport af: Lis Eilertzen, Kirsten Habekost, Lill Røn og Susanne Stender.
Vejleder: Klaus Grünbaum.

103/85 "ØDSLE KOLDKRIGERE OG VIDENSKABENS LYSE IDEER".
Projektrapport af: Niels Ole Dam og Kurt Jensen.
Vejleder: Bent Sørensen.

104/85 "ANALOGREGNEMASKINEN OG LORENZLIGNINGER".
Af: Jens Jæger.

105/85 "THE FREQUENCY DEPENDENCE OF THE SPECIFIC HEAT AF THE GLASS REANSITION".
Af: Tage Christensen.

"A SIMPLE MODEL AF AC HOPPING CONDUCTIVITY".
Af: Jeppe C. Dyre.
Contributions to the Third International Conference on the Structure of Non - Crystalline Materials held in Grenoble July 1985.

106/85 "QUANTUM THEORY OF EXTENDED PARTICLES".
Af: Bent Sørensen.

107/85 "EN MYG GØR INGEN EPIDEMI",
- flodblindhed som eksempel på matematisk modellering af et epidemiologisk problem.
Projektrapport af: Per Hedegård Andersen, Lars Boye, CarstenHolst Jensen, Else Marie Pedersen og Erling Møller Pedersen.
Vejleder: Jesper Larsen.

108/85 "APPLICATIONS AND MODELLING IN THE MATEMATICS CURRICULUM" - state and trends -
Af: Mogens Niss.

109/85 "COX I STUDIETIDEN" - Cox's regressionsmodel anvendt på studenteroplysninger fra RUC.
Projektrapport af: Mikael Wennerberg Johansen, Poul Katler og Torben J. Andreasen.
Vejleder: Jørgen Larsen.

110/85 "PLANNING FOR SECURITY".
Af: Bent Sørensen

111/85 JORDEN RUNDT PÅ FLADE KORT".
Projektrapport af: Birgit Andresen, Beatriz Quinones og Jimmy Staal.
Vejleder: Mogens Niss.

112/85 "VIDENSKABELIGGØRELSE AF DANSK TEKNOLOGISK INNOVATION FREM TIL 1950 - BELYST VED EKSEMPLER".
Projektrapport af: Erik Odgaard Gade, Hans Hedal, Frank C. Ludvigsen, Annette Post Nielsen og Finn Physant.
Vejleder: Claus Bryld og Bent C. Jørgensen.

113/85 "DESUSPENSION OF SPLITTING ELLIPTIC SYMBOLS 11".
Af: Bernhelm Booss og Krzysztof Wojciechowski.

114/85 "ANVENDELSE AF GRAFISKE METODER TIL ANALYSE AF KONTIGENSTABELLER".
Projektrapport af: Lone Biilmann, Ole R. Jensen og Arne-Lise von Moos.
Vejleder: Jørgen Larsen.

115/85 "MATEMATIKKENS UDVIKLING OP TIL RENESSANCEN".
Af: Mogens Niss.

116/85 "A PHENOMENOLOGICAL MODEL FOR THE MEYER-NELDEL RULE".
Af: Jeppe C. Dyre.

117/85 "KRAFT & FJERNVARMEOPTIMERING"
Af: Jacob Mørch Pedersen.
Vejleder: Bent Sørensen

118/85 "TILFÆLDIGHEDEN OG NØDVENDIGHEDEN IFØLGE PEIRCE OG FYSIKKEN".
Af: Peder Voetmann Christiansen

119/86 "DET ER GANSKE VIST - - EUKLIDS FEMTE POSTULAT KUNNE NOK SKABE RØRE I ANDEDAMMEN".
Af: Iben Maj Christiansen
Vejleder: Mogens Niss.

120/86 "ET ANTAL STATISTISKE STANDARDMODELLER".
Af: Jørgen Larsen

121/86 "SIMULATION I KONTINUERT TID".
Af: Peder Voetmann Christiansen.

122/86 "ON THE MECHANISM OF GLASS IONIC CONDUCTIVITY".
Af: Jeppe C. Dyre.

123/86 "GYMNASIEFYSIKKEN OG DEN STORE VERDEN".
Fysiklærerforeningen, IMFUFA, RUC.

124/86 "OPGAVESAMLING I MATEMATIK".
Samtlige opgaver stillet i tiden 1974-jan. 1986.

125/86 "UVBY,β - systemet - en effektiv fotometrisk spektralklassifikation af B-,A- og F-stjerner".
Projektrapport af: Birger Lundgren.

126/86 "OM UDVIKLINGEN AF DEN SPECIELLE RELATIVITETSTEORI".
Projektrapport af: Lise Odgaard & Linda Szkotak Jensen
Vejledere: Karin Beyer & Stig Andur Pedersen.

127/86 "GALOIS' BIDRAG TIL UDVIKLINGEN AF DEN ABSTRAKTE ALGEBRA".
Projektrapport af: Pernille Sand, Heine Larsen & Lars Frandsen.
Vejleder: Mogens Niss.

128/86 "SMÅKRYB" - om ikke-standard analyse.
Projektrapport af: Niels Jørgensen & Mikael Klintorp.
Vejleder: Jeppe Dyre.

129/86 "PHYSICS IN SOCIETY"
Lecture Notes 1983 (1986)
Af: Bent Sørensen

130/86 "Studies in Wind Power"
Af: Bent Sørensen

131/86 "FYSIK OG SAMFUND" - Et integreret fysik/historieprojekt om naturanskuelsens historiske udvikling og dens samfundsmæssige betingethed.
Projektrapport af: Jakob Heckscher, Søren Brønd, Andy Wierød.
Vejledere: Jens Høyrup, Jørgen Vogelius, Jens Højgaard Jensen.

132/86 "FYSIK OG DANNELSE"
Projektrapport af: Søren Brønd, Andy Wierød.
Vejledere: Karin Beyer, Jørgen Vogelius.

133/86 "CHERNOBYL ACCIDENT: ASSESSING THE DATA. ENERGY SERIES NO. 15.
AF: Bent Sørensen.

134/87 "THE D.C. AND THE A.C. ELECTRICAL TRANSPORT IN AsSeTe SYSTEM"
Authors: M.B.El-Den, N.B.Olsen, Ib Høst Pedersen, Petr Viščor

135/87 "INTUITIONISTISK MATEMATIKS METODER OG ERKENDELSESTEORETISKE FORUDSÆTNINGER"
MASTEMATIKSPECIALE: Claus Larsen
Vejledere: Anton Jensen og Stig Andur Pedersen

136/87 "Mystisk og naturlig filosofi: En skitse af kristendommens første og andet møde med græsk filosofi"
Projektrapport af Frank Colding Ludvigsen
Vejledere: Historie: Ib Thiersen
Fysik: Jens Højgaard Jensen

137/87 "HOPMODELLER FOR ELEKTRISK LEDNING I UORDNEDE FASTE STOFFER" - Resume af licentiatafhandling
Af: Jeppe Dyre
Vejledere: Niels Boye Olsen og Peder Voetmann Christiansen.

138/87 "JOSEPHSON EFFECT AND CIRCLE MAP."

Paper presented at The International Workshop on Teaching Nonlinear Phenomena at Universities and Schools, "Chaos in Education". Balaton, Hungary, 26 April-2 May 1987.

By: Peder Voetmann Christiansen

139/87 "Machbarkeit nichtbeherrschbarer Technik durch Fortschritte in der Erkennbarkeit der Natur"

Af: Bernhelm Booss-Bavnbek
Martin Bohle-Carbonell

140/87 "ON THE TOPOLOGY OF SPACES OF HOLOMORPHIC MAPS"

By: Jens Gravesen

141/87 "RADIOMETERS UDVIKLING AF BLODGASAPPARATUR - ET TEKNOLOGIHISTORISK PROJEKT"

Projektrapport af Finn C. Physant

Vejleder: Ib Thiersen

142/87 "The Calderón Projektor for Operators With Splitting Elliptic Symbols"

by: Bernhelm Booss-Bavnbek og
Krzysztof P. Wojciechowski

143/87 "Kursusmateriale til Matematik på NAT-BAS"

af: Mogens Brun Heefelt

144/87 "Context and Non-Locality - A Peircan Approach

Paper presented at the Symposium on the Foundations of Modern Physics The Copenhagen Interpretation 60 Years after the Como Lecture. Joensuu, Finland, 6 - 8 august 1987.

By: Peder Voetmann Christiansen

145/87 "AIMS AND SCOPE OF APPLICATIONS AND MODELLING IN MATHEMATICS CURRICULA"

Manuscript of a plenary lecture delivered at ICMTA 3, Kassel, FRG 8.-11.9.1987

By: Mogens Niss

146/87 "BESTEMMELSE AF BULKRESISTIVITETEN I SILICIUM"

- en ny frekvensbaseret målemetode.

Fysikspeciale af Jan Vedde

Vejledere: Niels Boye Olsen & Petr Viščor

147/87 "Rapport om BIS på NAT-BAS"

redigeret af: Mogens Brun Heefelt

148/87 "Naturvidenskabsundervisning med Samfundsperspektiv"

af: Peter Colding-Jørgensen DLH
Albert Chr. Paulsen

149/87 "In-Situ Measurements of the density of amorphous germanium prepared in ultra high vacuum"

by: Petr Viščor

150/87 "Structure and the Existence of the first sharp diffraction peak in amorphous germanium prepared in UHV and measured in-situ"

by: Petr Viščor

151/87 "DYNAMISK PROGRAMMERING"

Matematikprojekt af:
Birgit Andresen, Keld Nielsen og Jimmy Staal

Vejleder: Mogens Niss

152/87 "PSEUDO-DIFFERENTIAL PROJECTIONS AND THE TOPOLOGY OF CERTAIN SPACES OF ELLIPTIC BOUNDARY VALUE PROBLEMS"

by: Bernhelm Booss-Bavnbek
Krzysztof P. Wojciechowski

153/88 "HALVLEDERTEKNOLOGIENS UDVIKLING MELLEM MILITÆRE OG CIVILE KRÆFTER"

Et eksempel på humanistisk teknologihistorie
Historiespeciale

Af: Hans Hedal

Vejleder: Ib Thiersen

154/88 "MASTER EQUATION APPROACH TO VISCOUS LIQUIDS AND THE GLASS TRANSITION"

By: Jeppe Dyre

155/88 "A NOTE ON THE ACTION OF THE POISSON SOLUTION OPERATOR TO THE DIRICHLET PROBLEM FOR A FORMALLY SELFADJOINT DIFFERENTIAL OPERATOR"

by: Michael Pedersen

156/88 "THE RANDOM FREE ENERGY BARRIER MODEL FOR AC CONDUCTION IN DISORDERED SOLIDS"

by: Jeppe C. Dyre

157/88 " STABILIZATION OF PARTIAL DIFFERENTIAL EQUATIONS BY FINITE DIMENSIONAL BOUNDARY FEEDBACK CONTROL: A pseudo-differential approach."

by: Michael Pedersen

158/88 "UNIFIED FORMALISM FOR EXCESS CURRENT NOISE IN RANDOM WALK MODELS"

by: Jeppe Dyre

159/88 "STUDIES IN SOLAR ENERGY"

by: Bent Sørensen

160/88 "LOOP GROUPS AND INSTANTONS IN DIMENSION TWO"

by: Jens Gravesen

161/88 "PSEUDO-DIFFERENTIAL PERTURBATIONS AND STABILIZATION OF DISTRIBUTED PARAMETER SYSTEMS:

Dirichlet feedback control problems"

by: Michael Pedersen