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# On diffeological principal bundles of non-formal pseudo-differential operators over formal ones

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Let  $E$  be a complex vector space over a compact boundaryless manifold  $M$ . In this communication,  $G$  denotes either the group of non-formal, invertible bounded classical pseudodifferential operators or the group of invertible elements of the algebra of non-formal, maybe unbounded, classical pseudodifferential operators of integer order, equipped with a given diffeology which makes classical composition and inversion smooth.  $H$  is the normal subgroup of  $G$  of operators which are equal to  $Id$  up to a smoothing operator. We also assume that the group  $H$  is regular for its subgroup diffeology. We analyze the short exact sequence

$$Id \rightarrow H \rightarrow G \rightarrow G/H \rightarrow Id,$$

where  $G/H$  is understood as a group of formal pseudodifferential operators, along the lines of the theory of principal bundles, where,  $G$  is the total space,  $G/H$  is the base space and  $H$  is the structure group.

**Problem 1.** There is actually no local slice  $G/H \rightarrow G$ , or in other words the principal bundle  $G \rightarrow G/H$  has no known local trivialization.

Therefore, one has to consider what has been called by Souriau as "structure quantique" in [4] and diffeological connections along the lines of Iglesias-Zemmour [1] in order to interpret the so-called smoothing connections described in [2] (that we generalize here for  $S^1$  to any  $M$ ) in terms of horizontal paths. More precisely, we show:

**Theorem 2.** Any smoothing connection in the sense of [2] defines a diffeological connection along the lines of [1].

and we explain how one can understand the notion of curvature of covariant derivatives, with values in smoothing operators, in terms of curvature of a connection 1-form on  $G \rightarrow G/H$ .

Then, we specialize to  $M = S^1$ , by giving more examples of smoothing connections, and explain in this context how the Schwinger cocycle is, in cohomology, a first Chern form of the principal bundle  $G \rightarrow G/H$  for a given smoothing connection. We finish the exposition of the results by showing that higher Chern forms  $tr(\Omega^k)$  of this connection with curvature  $\Omega$  define closed  $2k$ -cocycles on the Lie algebra of  $G$ , and that the cocycle obtained for  $k = 2$  is non trivial, along the lines of [3].

As a conclusion, we give open problems related both to our construction and to the interpretation of index-like problems on pseudodifferential operators.

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## Зміст

<b>M. Amram</b> <i>On the algorithm of degenerations and fundamental groups as a tool to understand algebraic surfaces</i>	<b>2</b>
<b>D. Bolotov</b> <i>Foliations on closed three-dimensional Riemannian manifolds with a bounded mean curvature of leaves</i>	<b>3</b>
<b>Enzo Bonacci</b> <i>Topological issues about the 6D ISST in Physics</i>	<b>4</b>
<b>Francisco Bulnes</b> <i>Characterized cycles integration on <math>\mathcal{D}</math>-modules as solutions in <math>\mathbb{L}</math>-holomorphic bundles</i>	<b>5</b>
<b>D. Cheban</b> <i>One-dimensional Monotone Non-autonomous Dynamical Systems and Strange Nonchaotic Attractors</i>	<b>6</b>
<b>Y. Cherevko, V. Berezovski, J. Mikeš, Y. Fedchenko</b> <i>Holomorphically Projective Mappings of Kähler Manifolds Preserving The Generalized Einstein Tensor</i>	<b>8</b>
<b>V. Chernov, R. Sadykov</b> <i>Some questions about virtual Legendrian knots</i>	<b>10</b>
<b>Luca Di Beo</b> <i>Morse-Smale flows in the Boy's surface</i>	<b>11</b>
<b>Yu. Drozd</b> <i>Morita equivalence of non-commutative Noetherian schemes</i>	<b>12</b>
<b>K. Eftekharinasab</b> <i>Some critical point results for Fréchet manifolds</i>	<b>14</b>
<b>V. Fedorchuk, V. Fedorchuk</b> <i>On partial preliminary group classification of some class of <math>(1 + 3)</math>-dimensional Monge-Ampere equations. One-dimensional Galilean Lie algebras.</i>	<b>16</b>
<b>N. Glazunov</b> <i>On packing and lattice packing of Minkowski-Chebyshev balls</i>	<b>18</b>
<b>Omer GOK</b> <i>Unbounded order and norm convergence of some operators on Banach lattices</i>	<b>20</b>
<b>J. Ham, J. Lee</b> <i>An explicit formula for the A-polynomial of the knot with Conway's notation <math>C(2n, 4)</math></i>	<b>21</b>
<b>N. Konovenko</b> <i>The symplectic invariants of 3-webs</i>	<b>23</b>
<b>Yaacov Kopeliovich</b> <i>Solutions to Mumford's second problem on theta functions</i>	<b>25</b>
<b>I. Kuznietsova, Yu. Soroka</b> <i>Geometric interpretation of first Betti numbers of orbits of smooth functions</i>	<b>26</b>
<b>J-P. Magnot</b> <i>On diffeological principal bundles of non-formal pseudo-differential operators over formal ones</i>	<b>28</b>
<b>S. Maksymenko</b> <i>Topological actions of wreath products</i>	<b>29</b>
<b>J-L. Mo</b> <i>The geometrical properties of degenerations of curves and surfaces</i>	<b>30</b>
<b>P. Mormul</b> <i>Nilpotent approximations in the Goursat Monster Tower</i>	<b>32</b>