MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

T a g u n g s b e r i c h t 19 /1980

Gruppentheorie

27.4. bis 3.5.1980

Die diesjährige Gruppentheorie-Tagung stand unter der Leitung der Professoren W. Gaschütz (Kiel), K. Gruenberg (London) und B. Huppert (Mainz). Ein Drittel der Vorträge handelte von dem Gebiet der unendlichen Gruppen. Die modulare Darstellungstheorie endlicher Gruppen, die Theorie der endlichen auflösbaren Gruppen sowie ihrer Automorphismengruppen waren weitere Schwerpunkte.

Vortragsauszüge

D. BENSON:

The simple group J_4

Recently in Cambridge, S. Norton, J. Conway, R. Parker, J. Thackray and I have produced a pair of 112×112 matrices over GF(2) and proved that they generate a group of type J_4. I shall be describing the construction of these matrices and the proof that the group they generate is indeed of type J_4. (Incidentally, the uniqueness question has also now been settled by John Thompson.)

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R. BIERI:

Finiteness conditions for modules over a finitely generated Abelian group

Let Q be a f. g. Abelian group and A a finitely generated Q-module. In a joint paper with Ralph Strebel (to appear in Proc. London Math. Soc.) we attached to A an open subset $\Sigma_A \subseteq S^{n-1}$ of the (n-1)-sphere. This talk was a report on joint work with J.R.J. Groves. We term A m-tame, if every m-point subset of the set theoretic complement $\Sigma_A^c = S^{n-1} \setminus \Sigma_A$ is contained in an open hemisphere and conjecture: If $A \triangleleft G$ with $G/A = Q$ then G admits a projective resolution which is finitely generated in dimensions $\leq m$ if and only if A is m-tame. The "only" if part of the conjecture is then "proved over a field".

A. BRANDIS:

Methods in transfer

Let G be a finite group, p a prime, P a p-Sylow subgroup of G and $P \leq H \leq G$. Let $T_H = H \cap O^p(G)$. We call a set $S \subset P$ totally H-covering iff $\langle S\rangle \cdot O^p(H) \geq T_H$, where $\langle S\rangle$ is the subgroup generated by S. The following theorem holds:

Theorem: Let Q be a weakly closed subgroup of P resp. G, and $H \geq N_G(Q)$. Then

$$S = \{[t,y;\, p-1]^x \in P \,,\ t \in P \,,\ y \in Q \,,\ x \in G\} \cup [Q,P]$$

is totally H-covering, where $[t,y;\, i] = [[t,y;\, i-1],y]$.

As a corollary one has

Theorem: Let Q be strongly closed in P resp. G and $H \geq N_G(Q)$.
Then $Q \cdot O^p(H) \geq T_H$.

This generalizes slightly a theorem by H. Wielandt. Outlines are given how to gain Yoshida's results on transfer.

A. R. CAMINA:

Permutation Groups

Let G be a permutation group on a set Ω. Assume for each natural number, $\Omega^{(r)}$ is the set of subsets of r elements of Ω.

Hypothesis (r): For any two $\Delta, \Gamma \in \Omega^{(r)}$ $|G_\Delta| = |G_\Gamma| > 1$ where $G_\Delta = \{ g \mid \alpha g = \alpha \quad \forall \alpha \in D \}$.

Such a group is called r-uniform.

Theorem: If G is 1-uniform and G_α is Abelian $\forall \alpha \in \Omega$ then G is transitive.

Question (r): Does G being r-uniform imply G is r + $^1/_2$-transitive?

Note if the answer to Question (r) is yes then it is yes for all $s \geq r$.

I.M. CHISWELL:

Aspherical group presentations

A group presentation <X;R> is aspherical if the usual 2-dimensional complex K(X;R) realising <X;R> is aspherical. We can generalise this notion to obtain three classes of presentations: combinatorially aspherical (CA), diagrammatically aspherical (DA) and Cohen-Lyndon aspherical (CLA). They are connected by the implications CLA ==> DA ==> CA , and it is known that CA ≠> DA . All three classes have nice closure properties, under taking free products with amalgamation, HNN-extensions, and under taking Reidemeister-Schreier presentations of subgroups.

J. COSSEY:

Subgroup closed Fitting classes

R.A. Bryce and I have established that a subgroup closed Fitting class of finite soluble groups is a formation. I will aim to give a brief description of the main steps in the proof.

P. FONG:

Brauer trees in classical groups

Let G = GL(n,q) or U(n,q), and let r be an odd prime not dividing q . Bhama Srinivasan and I have shown that if B is an r-block of G with cyclic defect group, then the Brauer tree of B is an open polygon. When G = GL(n,q), we have explicit labelings for the nodes, but the corresponding problem for U(n,q) is unsettled. Our methods show a nice fit of the Brauer-Dade theory, the Deligne-Lusztig theory, and combinatorial properties of Young diagrams.

B. HARTLEY:

Centralizers of involutions in periodic groups

Let G be a periodic group containing an involution i . Some results are discussed relating the structure of G to the structure of $C_G(i)$, namely (1) if $C_G(i)$ is finite then $[G,i]'$ is finite and (2) if G is locally soluble (and so locally finite) and $C_G(i)$ is Černikov, then $[G,i]'$ is Černikov. Thus G contains normal subgroups $K \leq H$ such that H/K is abelian, and G/H and K are finite in case (1) and Černikov in case (2).

In the first result, when $C_G(i)$ is finite, a theorem of Šunkov shows that G is locally finite. The result then follows from the following (Hartley and Meixner): Let H be a finite group containing an involution i such that $|C_H(i)| \leq m$. Then H contains a nilpotent normal subgroup of class at most two and index bounded in terms of m .

D.F. HOLT:

Cohomology in Locally Finite Groups

All groups G are locally finite, $\pi(G)$ = primes dividing elements of G . Let N be a G-module, $\pi(G) \cap \pi(N) = \emptyset$.
Problem: When is $H^n(G,N) = 0$? Yes, if $|G| < \aleph_{n-1}$.
Conjecture: This condition is necessary. More precisely, let K = field of order p , $p \notin \pi(G)$. Conjecture: $cd_K G = n \iff |G| = \aleph_{n-1}$ or equiv. $gl.dim.(KG) = n \iff |G| = \aleph_{n-1}$.
This is known if n = 1 (Dunwoody). It is also true if G is hypercentral.

I shall discuss the cases n = 1 and 2 as often as possible, using interpretations in terms of complements and extensions, for the sake of those not familiar with cohomology groups.

M. JARDEN:

Free pro-finite groups

The following question has been posed:

Question: Suppose that a torsion free pro-finite group G contains $\hat{F}_e$ as an open subgroup. Is G free?

Here $\hat{F}_e$ denotes the free pro-finite group on e generators.

The corresponding questions for the category of discrete groups and for the category of pro-p-groups have positive answers (Stalling and Serre, respectively). The following theorem has been proved:

Theorem. If a torsion free pro-finite group G contains $\hat{F}_e$ as an open subgroup, then $(G:\hat{F}_e) \mid e-1$.

It follows that the question has an affirmative answer for e = 2 . There are counterexamples for e = 1 and $e = \omega$. The question is still open for $3 \leq e < \omega$.

O.H. KEGEL:

Highly transitive permutation groups

Every permutation group (G, Ω_G) may be embedded into a permutation group (H, Ω_H) which is highly transitive, i.e. n-transitive for every natural number n . In fact, if G is locally finite, H may be chosen locally finite. If G is locally finite, then H may be chosen locally finite and such that $(H, \Omega_H) \cong (H_\omega, \Omega_H \setminus \omega)$, if G and Ω are countable.

W. KNAPP:

On primitive permutation groups which indece a Frobenius group on a suborbit

Suppose (G,Ω) is a finite primitive permutation group such that for $\alpha \in \Omega$ the point stabilizer G_α induces on a suborbit $\Delta(\alpha)$ of length $d > 1$ a Frobenius group of order dh . Under this hypothesis the following holds:

Theorem: $|G_\alpha|$ divides dh^{d+1} . If $G_\alpha^{\Delta(\alpha)}$ is primitive and $d \neq 3$ then $|G_\alpha|$ divides dh^2 .

A proof of the theorem is sketched which is based on p-local analysis of G_α . The methods of the proof provide also for a short proof of Sims' "classical" result for the case $d = 3$ without using graph theory. (To appear in Oxford QJM 1980.)

H. KURZWEIL:

Einfache Gruppen als Automorphismengruppen auflösbarer Gruppen

Sei G auflösbar, endlich, $A \leq \mathrm{Aut}\, G$, $(|G|,|A|) = 1$. Dann ist die nilpotente Länge von G durch eine Funktion beschränkt, die allein von A und der nilpotenten Länge der Fixpunktgruppe $C_G(A)$ abhängt, falls für jeden einfachen nichtabelschn Kompositionsfaktor K von A 1) - 3) gelten:

1) Für jeden Abschnitt B von K gilt: Ist V ein treuer $\mathbb{F}_p B$-Modul, $p \in \pi(G)$, so existiert ein $v \in V$ mit $|v^B| = |B|$.
2) Jeder einfache nichtabelsche Abschnitt B von K besitzt eine auflösbare Untergruppe M mit der Eigenschaft: Ist V ein irreduzibler $\mathbb{F}_p B$-Modul, $p \in \pi(G)$, so ist $\dim C_V(M) \neq 1$.
3) Jede Untergruppe B von K ist entweder auflösbar oder modulo dem maximalen auflösbaren Normalteiler von B ein direktes Produkt von einfachen Gruppen.
Zum Beispiel besitzt $K = A_5$ diese Eigenschaften.

P. LANDROCK:

On centralizers of p-elements in liftable modules

Let p be a prime divisor of the order of G and let F be a field of characteristic p. For any F[G]-module M, we define the centralizer of a p-element x in M as $C_M(x) = \{m \in M \mid mx = m\}$. Let $c_M(x)$ denote the dimension of this space. In general, $M|_{\langle x\rangle}$ is only determined completely from dim M and $c_M(x)$ if p = 2 and x is an involution. We prove that $M|_{\langle x\rangle}$ is also completely determined if M is a direct summand of a permutation module (and consequently liftable by an observation due to L. Scott). Also, $c_M(x) = \chi_M(x)$ where χ_M is the character of M. In general, if M is only assumed to be liftable, one may obtain a lower bound for $c_M(x)$ which depends on the form of $\chi_M|_{\langle x\rangle}$. If p = 2 and x is an involution, this bound is merely $\frac{\chi_M(1) + \chi_M(x)}{2}$. The whole machinery may be applied to determine Green correspondents.

A. MANN:

Powerful p-groups

A p-group, p > 2, is powerful if $\mho_1(G) \geq G'$. Also, if $N \triangleleft G$, N is powerfully embedded in G if $\mho_1(N) \geq [N,G]$.

1. If G is powerful and $H \leq G$ then $d(H) \leq d(G)$. Here d(X) is the minimal number of generators of the group X.
2. If M,N are powerfully embedded in G, then so are MN, [M,N], $\mho_1(N)$ and [N,G]. In particular, if G is powerful, then $\mho_1(G_i) \geq G_{i+1}$.
3. If M,N are powerfully embedded, then
$$\mho_k([M,N]) = \prod_{i=0}^{k} [\mho_i(M), \mho_{k-i}(N)] .$$

It is also possible to modify the definitions so that they apply also to p = 2.

G. MICHLER:

The number of indecomposable lattices in a block of finite lattice type

Let G be a finite group, p a prime number dividing |G|. Let R be any finite unramified extension of $\hat{\mathbb{Z}}_p$ with quotient field S. Then generalizing a well-known theorem of Jones my student Chr. Bessenrodt showed recently in the Archiv d.Math.: A block B of a finite group G has only finitely many non-isomorphic RG-lattices if and only if its defect group $\delta(B) =_G D$ is cyclic of order $|D| \leq p^2$. If |D| = p, then B has 3t non-isomorphic RG-lattices.

The main result of this talk is the following

Theorem (Bessenrodt): Let B be a block of a finite groups G with cyclic defect group $\delta(B) =_G D = \langle x \rangle$ of order p^2 and inertial index t . Suppose that R is a finite unramified extension of $\hat{\mathbb{Z}}_p$ such that $F = R/\pi R$ is a splitting field for $H = N_G(D)$ and its subgroups. Then B has

a) t non-isomorphic indecomposable projective RG-lattices,

b) 2t non-isomorphic indecomposable RG-lattices U with vertex $vx(U) = \langle x^p \rangle$,

c) 2(2p-1)t non-isomorphic indecomposable RG-lattices U with $vx(U) =_G D$.

Corollary: Each non-projective indecomposable RG-lattice U of B is periodic with period 2t .

Corollary: There is a bijection between the Heller orbits of the non-projective indecomposable RD-lattices and the Heller orbits of the non-projective indecomposable RG-lattices of B . This bijection is vertex preserving.

J.B. OLSSON:

The canonical character

If B is a p-block of the finite group G with defect group D , then a block b of $DC_b(D)$ with $b^G = B$ is called a root of B . In a root b there is a unique character Θ having D in its kernel. This is the canonical character of B . Results of R. Brauer, especially Theorem (2D) in "Blocks and Sections II" (Amer.J.Math.) show that there are relations between characters in B and θ and $\theta^{N_G(D)}$. The canonical character is an interesting object to study in its own right. Some aspects and examples of this were discussed in the talk. The following holds in many examples: If B is a block of full defect in a group with an abelian Sylow p-subgroup D , then the number of modular irreducible characters in B equals the number of different irreducible characters of $N_G(D)$ occurring in $\theta^{N_G(D)}$. In some cases this observation is related to the Alperin-McKay conjecture.

H. PAHLINGS:

Minimal kernels and Frattini subgroups

For a finite group G and a field K of characteristic $p \geq 0$, let $\mathfrak{K}_p(G)$ denote the set of kernels (centralizers in G) of the irreducible KG-modules and $\mathfrak{M}_p(G)$ be the set of minimal elements (w.r.t. inclusion) of $\mathfrak{K}_p(G)$. It is shown that the elements of $\mathfrak{M}_0(G)$ have several properties in common with the Frattini subgroup $\Phi(G)$, and a class of normal subgroups of G is considered which contains $\mathfrak{M}_0(G)$ and $\Phi(G)$. For $p \neq 0$, $\Phi(G)$ is replaced by the intersection of the maximal subgroups of G with index prime to p . Finally, for a fixed prime p and a (Brauer-) p-block B , let $\mathfrak{K}_B$ be the set of kernels of the irreducible $\mathbb{C}G$-modules belonging to B and $\mathfrak{M}_B$ be the set of minimal elements of $\mathfrak{K}_B$. Properties of the normal subgroups in $\mathfrak{M}_B$ are discussed.

D.J.S. ROBINSON:

Recent results on finite complete groups

A survey will be given of recent work on the classification of finite soluble complete groups of small nilpotent length.

K. ROGGENKAMP:

A Note on the Geometry of Special Groups

Let $G_n = C_p^{(n)}$ and $k = \mathbb{F}_p$. K_n stands for the isomorphism classes of essential (Frattini) extensions

$$\mathcal{E}: 1 \longrightarrow k^{(m)} \longrightarrow E \longrightarrow G_n \longrightarrow 1 \text{ , n fixed,}$$

where k is the trivial G_n-module and morphisms are morphisms over G_n. These extensions are in bijection to the k-subspaces $V(\mathcal{E})$ in $H^2(G_n, k)$; i.e. to the elements in $\mathbb{P}(H^2(G_n, k))$, the projective space. The abelian extensions correspond to elements in $\mathbb{P}(V_{ab})$, where V_{ab} is a subspace of dimension n in $H^2(G_n, k)$. $\mathcal{E}$ has the property $E/E' \cong G_n$ iff $V(\mathcal{E}) \cap V_{ab} = 0$.
For $\varphi: G_n \longrightarrow G_{n-1}$ we put $V_\varphi = \mathrm{Im}(H^2(G_{n-1}, k) \longrightarrow H^2(G_n, k))$.
Let $\mathcal{E}_j$, $1 \leq j \leq t$, be the non-split extensions in $H^2(G_n, k)$ which are not extraspecial, and put $V_i = k\langle \mathcal{E}_i \rangle$ and $V_{\varphi,i} = V_\varphi + V_i$. Then $\dim_k H^2(G_n, k) = a(n) = \frac{n(n+1)}{2}$ and $\dim_k V_{\varphi,i} \leq a(n-1) + 1$. Then $\mathcal{E}$ is central, i.e. $Z(E) = k^{(m)}$ iff $V(\mathcal{E}) \not\subset V_{\varphi,i}$ for every φ, i.

J.S. ROSE:

The p-part of the Frattini subgroup

Some account was given of the following result. Let G be a finite p-soluble group, P a Sylow p-subgroup of G , and suppose that each subgroup of P is generated by at most 4 elements. Than either $P \cap \Phi(G) \leq \Phi(P)$ or: p = 3 and G involves a certain group G_0 of order $2^3 3^5$. Details will appear in J. reine angew. Math.

G. ROSENBERGER:

Über Gleichungen in freien Produkten mit Amalgam

Es werden einige Resultate über Gleichungen in freien Produkten mit Amalgam bewiesen, aus denen sich unter anderem als Folgerungen die Sätze von Kurosh über Untergruppen freier Produkte, von H. Neumann über Untergruppen freier Produkte mit Amalgam, von Grushko-B.H.Neumann über Erzeugendensysteme freier Produkte, von McCool-Pietrowski über Erzeugendensysteme freier Produkte mit normalem Amalgam und von Shenitzer über die Zerlegung von Einrelatorgruppen in freie Produkte ergeben (vgl. R.C.Lyndon, P.E.Schupp; Combinatorial group theory. Ergebnisse der Math. 189 (1977), Springer-Verlag). Dadurch werden diese wichtigen Sätze in einen allgemeinen Zusammenhang gestellt. Weiter erlauben diese Resultate einen allgemeinen Satz herzuleiten, durch den die bekannten Sätze von Nielsen über Automorphismen von Flächengruppen und von Schreier über Automorphismen von Torusknotengruppen entscheidend erweitert werden. Auch ergeben sich Sätze über Zerlegungen von Einrelatorgruppen in freie Produkte mit zyklischem Amalgam.

R. STEINBERG:

An occurrence of the Robinson-Schenstad correspondence

In a paper in Inventiones Math. 1976 I obtained a bijective correspondence between elements of the Weyl group W of a semisimple algebraic group G and G-orbits of pairs (u;C,C') consisting of a unipotent element u of G and a pair C,C' of components in the variety of flags fixed by u . Since such components arise in a number of different contexts related to desingularization questions, representations of Weyl groups, and of semisimple groups, it seems reasonable to make the correspondence explicit in the standard case $G = SL_n$. In that case W is S_n(symmetric group), u is represented by a partition λ of n and C,C' by standard Young tableaux of shape λ , and the correspondence turns out to be one discovered by Robinson and rediscovered by Schenstad and used in connection with representational and combinatorial results about S_n .

M. SUZUKI:

A cohomology-free proof of the splitting theorem of Gaschütz

A proof of the splitting theorem of Gaschütz will be given. It is based on the properties of the twisted wreath products which are defined by B.H. Neumann: Arch. Math. 14 (1963) 1-6.

J.G. THOMPSON:

Generalized Reflection Groups

Let Γ be a finite graph with vertex set $v(\Gamma)$, edge set $e(\Gamma)$. Let $G(\Gamma)$ be the group given by generators and relations:

$$G(\Gamma) = gp\langle x_i \mid i \in v(\Gamma),\ x_i^2 = 1,\ (x_i x_j)^{a_{ij}} = 1,$$
$$a_{ij} = \begin{cases} 2 & \text{if } \{i,j\} \notin e(\Gamma) \\ 3 & \text{otherwise} \end{cases} \rangle$$

Form an integral lattice $\Lambda(\Gamma)$ which has $\{\lambda_i \mid i \in v(\Gamma)\}$ as a $\mathbb{Z}$-basis, and where

$$(\lambda_i, \lambda_i) = 2, \quad (\lambda_i, \lambda_j) = \begin{cases} 0 & \text{if } \{i,j\} \notin e(\Gamma) \\ -1 & \text{otherwise} \end{cases}.$$

Then $G(\Gamma)$ acts on $\Lambda(\Gamma)$ via

$$x_i : \lambda \longmapsto \lambda - (\lambda_i, \lambda) \cdot \lambda_i \qquad (\lambda \in \Lambda).$$

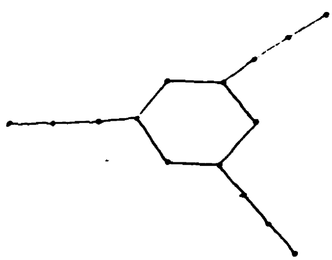
From Steinberg, Gruenberg and Solomon I learned of the following well known theorems:

(1) $G(\Gamma)$ acts faithfully on $\Lambda(\Gamma)$. (Bourbaki, Groupes et algebres de Lie, Chap. V, Corollaire 2, p.93).

(2) $G(\Gamma)$ has a subgroup of finite index and finite cohomological dimension. (Prospects in Math., Annals of Math., # 70; Serre's article, p. 107).

From (2), it follows that if p is a prime and $G(\Gamma)$ has an element of order p, then Γ contains a subgraph of type A_{p-1}.

If Γ_0 denotes the graph



then the determinant of $\Lambda(\Gamma_0)$ is $-2^3 3^3$ and $\Lambda(\Gamma_0)$ has signature (14,1). Mennicke noted that $G(\Gamma_0)$ is of infinite index in $G_{\Lambda(\Gamma_0)}$, the group of isometries of $\Lambda(\Gamma_0)$, and that $G_{\Lambda(\Gamma_0)}$ does not satisfy the congruence subgroup theorem. From Fischer, we know that the monster group M , if it exists, is a quotient group of $G(\Gamma_0)$. Might it not be possible to exhibit explicitly a fundamental domain for $G(\Gamma_0)$ and thereby determine geometrically a homomorphism $G(\Gamma_0) \longrightarrow M$? This is a tall order, but more generally, it may be worthwhile to pursue the study of graphs Γ such that $\Lambda(\Gamma)$ has signature (n,1). Relevant results, it would appear, may be found in Discrete Subgroups of Lie Groups and Applications to Moduli, Bombay Colloquium, 1973 (especially Vinberg's article) and in Notre Dame Lecture Notes, Reflection Groups, by Koszul.

R.W. VAN DER WAALL:

Embedding of non-M-groups

A survey was given on the following results.

Theorem 1: Let G be a finite monomial group. Let $N \lhd G$. Assume that all maximal subgroups of N are monomially closed. Then N is monomial or $O_{2'}(N) \neq O^2(N)$.

Corollary: Consider a solvable minimal non-M-group K for which $O_{2'}(K) = O^2(K)$. [That is K/F(K), (F(K) Fitting subgroup of K), is not dihedral of order 2s, s odd prime]. Then $K \lhd G$ implies G is not monomial.

The proof of theorem 1 uses very strongly the classification of the solvable minimal non-M-groups as obtained in a series of papers in Indagationes Mathematicae (1975-1980).

P.J. WEBB:

Minimal relation modules

Let $1 \longrightarrow R \longrightarrow F \longrightarrow G \longrightarrow 1$ be a presentation for the group G. The abelian group R/R' is called a relation module for G, and it has the structure of a $\mathbb{Z}G$-module. It is said to be minimal if the rank of F equals the minimum number of generators of G. In this lecture it is shown that certain free nilpotent groups have infinitely many non-isomorphic minimal relation modules. Formulae are also given for the number of minimal relation modules when G is a finite abelian group, and for the size of the genus to which these modules belong.

U. WEBB:

An elementary proof of a theorem of Gaschütz

It was proved by Gaschütz that any non-cyclic finite p-group admits a non-inner automorphism of p-power order. I give an elementary proof of this and describe recent extensions of the theorem.

B.A.F. WEHRFRITZ:

Residual finiteness of generalized free products

We outline a unified proof of four known theorems giving conditions ensuring the residual finiteness of a generalized free product and derive generalizations of these theorems that seem to have gone unrecorded before.

H. WIELANDT:

Criteria for subnormality in factorized groups

Let G be a finite group with subgroups H,K such that G = HK . Let A be any subgroup of G. Then each of the following conditions implies A sn G: (1) A sn H and A sn K . (2) A sn <A,H> and A sn <A,K>. (3) A sn $AA^x = A^xA$ for every $x \in H \cup K$.
(1) has been conjectured (and proved for soluble A) by R. Maier, Bol.Soc.Bras.Mat.8 (1977). The question whether (3') A sn $\langle A,A^x\rangle$ or (3") $AA^x = A^xA$, for every $x \in H \cup K$, implies A sn G remains open.

H. Laue (Kiel)

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