

Navier-Stokes Hoteisiki no Kai no Sonzai, Itiisei, Anteisei

----- Buturiteki Koozatu.

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1. Hasigaki

Nensei-Ryuutai no Undoo wa Navier-Stokes Hoteisiki ni yotte
sikai-sareru. Kono Hoteisiki no suugakuteki Seisitu -- Kai no Sonzai,
Itiisei, Anteisei -- ga ryuutai-rikigaku-tekini dono yooni Imi o motu ka
ni tuite noberu. Suugaku-tekini genmituna Urazuke no nai Okusoku de aru
ga, kore ni tuite Suugakusya no go-Iken o o-kiki sitai to omou. Mata,
Ryuutai-Rikigaku no Senmonka no naka ni mo, Hissya no Kangae ni kanarazu-
simo sansei sarenai kata mo sukunaku nai koto to omowareru ga, Wadai o
dasu Imi de, Matomari no nai Katati no mama de kozin-tekina Kangae o noberu
koto o o-yurusi negaitai. Kono Mondai ni tuite Suugakusya oyobi Ryuutai-
Rikigakusya no Kansin o yobiokosu koto ga dekireba saiwai de aru.

2. Navier-Stokes Hoteisiki wa zituzaino Ryuutai no Undoo o arawasu ka?

Zituzaino Ryuutai wa, Ekilai ni sitemo, Kitai ni sitemo, musuuno
Bunsi no Syuudan de aru. Ryuutai-Rikigaku dewa korerano Bunsi no Syuudan
o tyuusyooka site, renzoku-tekina Baisitu tosite atukau. Tadasi, Tyuusyooka
no sai ni, Situryoo, Undooryoo, Enerugii no Hozon-Hoosoku wa sono mama
saiyoo-sarete, Ryuutai no Undoo ni taisuru Kiso-Hoteisiki ga mitibikareru.
Iwayuru Renzoku no Hoteisiki wa Situryoo no Hozon o, mata Undoo-Hoteisiki
wa Undooryoo no Hozon o teisikika sita mono de aru. Renzoku no Hoteisiki

oyobi Undoo-Hooteisiki wa sorezore

$$\frac{\partial p}{\partial t} + \text{div } \rho \mathbf{v} = 0, \quad (1)$$

$$\rho \frac{D\mathbf{v}}{Dt} = \rho \mathbf{K} + \frac{\partial p_{ik}}{\partial x_k}, \quad \frac{D}{Dt} \equiv \frac{\partial}{\partial t} + v_k \frac{\partial}{\partial x_k} \quad i, k = 1, 2, 3 \quad (2)$$

no Katati ni arawasareru. Kokoni ρ wa Mitudo, $\mathbf{K}$ wa (Ryuutai no Tan-i Situryoo atarino) Gairyoku, p_{ik} wa Ryuutai no nakani sonzaisuru Ooryoku de aru. (1), (2) wa nin-ino Ryuutai ni tuite naritatu node aru ga, tokuni Ooryoku p_{ik} ni taisite

$$p_{ik} = -p \delta_{ik} + \tau_{ik}, \quad (3)$$

$$\tau_{ik} = \mu \left(\frac{\partial v_i}{\partial x_k} + \frac{\partial v_k}{\partial x_i} \right) \quad (4)$$

o kateisuru no ga Newton-Ryuutai, sunawati Newton no Nensei-Hoosoku ni sitagau Nensei-Ryuutai de aru. τ_{ik} wa Nensei-Ooryoku, μ wa Nenseiritu de aru. Sarani, Mitudo ρ to Nenseiritu μ o ittei to kateisuru to, (1), (2) wa sorezore

$$\text{div } \mathbf{v} = 0 \quad (5)$$

$$\frac{D\mathbf{v}}{Dt} = \mathbf{K} - \frac{1}{\rho} \text{grad } p + \nu \Delta \mathbf{v}, \quad \nu = \frac{\mu}{\rho} \quad (6)$$

to kantanni naru. (6) ga hutuuni Navier-Stokes Hooteisiki to yobareru mono de aru. ν wa Undoo-Nenseiritu de aru.

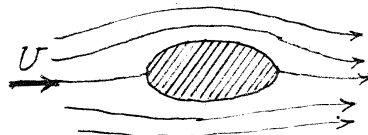
Oyoso Ryuutai no Assyukusei ga musu dekiru baai, mata Nenseiritu o ittei to minasi-uru baai wa, Ryuutai no Undoo wa (5), (6) ni yotte kanzenni arawaseru mono to kitai sareru. Sitagatte, (5), (6) no Renritu-Henbibun-Hooteisiki ($\mathbf{v}$, p o Mitisuu to suru) no suugakuteki Seisitu ga kanzenni sirareru naraba, tizimanai Nensei-Ryuutai no Undoo ga rirontekini kanzenni siriuru hazu de aru. Tatoeba, itiyoono Nagare no naka ni Kyuu o seisi saseta toki, Reynolds-suu ni yotte Nagare no Yoosu wa kiwamete hukuzatuni henkasuru

ga, kore wa N-S Hootesiki ni yotte kanzenni iiarawaseru hazu de aru. Zissai soo daroo ka? Reynolds-suu no tiisai baai ni okoru Sooryuu no Zyootai kara Reynolds-suu no ookii baai no Ranryuu no Zyootai e no Sen-i-Gensyoo ga N-S Hootesiki dake o Kiso ni site setumei sareru node aroo ka? Mata, Ranryuu no Zyootai sono mono mo, N-S Hootesiki no Suugakuteki-Seisitu dake de kanzenni setumei dekiru node aroo ka? Kore ni kotaeru tame niwa, N-S Hootesiki ni tuite wareware no genzai motu Tisiki wa amarinimo sukunasugiru. Kono Note dewa, Ryuutai-Gensyoo ni kansuru Tisiki kara gyakuni, N-S Hootesiki no Kai no suugakuteki Seisitu ni tuite dono yoono Kotogara ga soozoo sareru ka o noberu. Korera no Okusoku ga hatasite tadasii ka, matawa matigatte iru ka? Suugakusya no katagata ni Kyoomi o motte itadaki, Kaitoo o ataete kudasareba, makotoni saiwai de aru.

3. Teizyoona Nagare

Mazu, mottomo kantanna baai tosite, Kyookai-Zyookken ga zikantekini ittei, sunawati "teizyoona Nagare" o kangaeru. Tatoeba, itiyoono Nagare no naka ni Buttai o seisi saseta toki no Nagare de aru (Zu. 1). Tyokkantekini wa, kono baai, Nagare wa teizyoo de aroo to kitai sareru. Sunawati, Sokudo ∇ wa Zikan t ni wa yoranai daroo.

(Gairyoku K wa N-S Hootesiki no Seisitu ni honsitu-tekina Eikyoo o motanai to yosoo sareru node, korekarano Giron dewa $K = 0$ to suru.) Sitagatte, N-S Hootesiki tosite wa



Zu. 1

$$(\nabla \cdot \text{grad}) \mathbf{v} = -\frac{1}{\rho} \text{grad } p + \nu \Delta \mathbf{v} \quad (7)$$

o saiyooosureba yoi.

Sate, mazu Mondai ni naru no wa, "buturi-tekini tekitoo to kangae-

rareru" Kyookai-Zyookken:

$$V = 0$$

Buttai no Hyoomen

(8)

$$V \rightarrow (U, 0, 0)$$

Mugen-en

no motoni Renritu-Henbibun-Hootetisiki (5), (7) ga Kai o motu ka, to iu koto de aru. Kore wa Kai no "Sonzai" no Mondai de aru. Genzai, suugaku-tekini genmituni ieru no wa, "Reynolds-suu $R = U/1/\nu$ (1 wa daihyoo-tekina Nagasa) ga tekitooni tiisakereba Kai wa sonzaisuru" to iu koto de aru (TAKAMI no Kaisetu o miyo!). Ryuutai-Rikigakusya tosite siritai no wa, "Kai wa R no subeteno Atai ni taisite sonzaisuru no ka, soretomo aru Rinkai-ti R_{ex} ga atte, $R < R_{ex}$ dewa Kai wa sonzaisi, $R > R_{ex}$ dewa sonzaisinai no ka? Mosi sooda to sureba, R_{ex} no gutaitekina Atai wa nani ka," to iu koto de aru.

Zissaino Gensyoo dewa, R ga tiisai toki Nagare wa ippanni Sooryuu, R ga ookii toki Ranryuu de aru. Sono Sakai no R ga iwayuru Rinkai-Reynolds suu R_c de aru. Kono R_c ga ueni nobeta R_{ex} ni ittisuru naraba Hanasi wa kantan de aru. Tumari, Teizyoo-Kai ga sonzaisinai kara Hiteizyoo-Kai ga arawareru no da, to iesoo de aru.

Sikasi, mosimo $R_{ex} = \infty$, sunawati, Teizyoo-Kai ga tuneni sonzai suru naraba, koto wa mendoo de aru. Kono baai kangaerareru no wa, Kai no "Anteisei" no Mondai de aru. Sunawati, aru Reynolds-suu R_{st} ga atte, $R < R_{st}$, $R > R_{st}$ ni oozite sorezore Kai ga antei aruiwa huantei de aru koto ga wakaruru naraba, ueno R_c o kono R_{st} to kaisyakusuru koto ga dekiyoo. (Ryuutai-Rikigakusya ni totte wa kono Kaisyaku ga mottomo sizen de aru yooni omowareru!)

Mada Mondai ga aru. Teizyoo-Kai ga sonzaisuru to site mo, sore wa kanarazusimo itii-tekini kimaru towa ienai. Hatasite, Kai no "Itiisei" wa hosyoosareru no ka? Boo ya Ita no Zakutu (buckling) no Rei demo yoku sirarete iru yooni, hisenkeino Mondai dewa Kai ga itii-tekini kimaranai no

ga musiro hutuu de aru. N-S Hoteisiki no baai wa doo ka? Mosimo Kai ga 2-ko izyoo sonzaisuru naraba, genzituni arawareru no wa dore ka? Sono baai, Kai no Anteisei ga zyuuyooona Mondai ni naru de aroo. Sunawati, Zissai-Gensyoo ni taiosuru no wa anteina Kai de aroo. Sitagatte, kazu-ooku sonzaisuru Kai wa takadaka 1-ko o nozoite subete huantei de aru mono to soozoo sareru. (Kai ga subete huantei de aru koto mo ariuru. Sono baai Sooryuu wa okori-enai.)

Soredewa, teizyooona Kyookai-Zyookan ni taisuru Kai wa tuneni teizyoo de aroo ka? Senkeino Mondai no Keiken kara tanzyunni kangaeru to, sono yooni soozoo sareru kamo sirenai. Sikasi, hisenkeino Mondai dewa kanarazusimo soo da towa iikirenai yooni omowareru. Musiro, N-S Hoteisiki no baai wa, teizyooona Kyookai-Zyookan ni taisite hiteizyooona Kai ga sonzaisi, sore ga Ranryuu no Zyootai ni taiosuru no dewa nai ka to soozoo sareru.

4. Okusoku

Ima, $f(0; E, U, S)$, $f(t; E, U^*, S^*)$ no yooona Kigoo o mitibiki-ireru. Dai-1 no Hikikazu 0, t wa sorezore Teizyoo-Kai, Hiteizyoo-Kai o imisuru. E, U, S wa sorezore, Sonzai, Itiisei, Anteisei o imisi, * Zirusi wa Hitei o imisuru. Sitagatte, tatoeba $f(0; E, U, S)$ wa "Teizyoo-Kai ga tada 1-ko sonzaisite, sore ga antei de aru" koto o imisuru. Mata $f(t; E, U^*, S^*)$ wa "Hiteizyoo-Kai ga 2-ko izyoo sonzaisi, sorera wa huantei de aru" koto o imisuru. Kono yooni yakusokusureba, wareware no Okusoku wa tugino yooni Hyoo no Katati ni kakiarawaseru.

$$f(0; E, U, S) = \text{Sooryuu}, \quad f(t; E, U, S) = \text{No} \quad (01)$$

$$f(0; E, U, S^*) = \text{No ?} \quad f(t; E, U, S^*) = \text{No} \quad (02)$$

$$f(0; E, U^*, S) = \text{Taylor-Uzu etc.} \quad f(t; E, U^*, S) = \text{Karman-Uzu etc.} \quad (03)$$

$$f(0; E, U^*, S^*) \longrightarrow f(t; E, U^*, S^*) = \text{Ranryuu} \quad (04)$$

$$f(0; E^*) \longrightarrow f(t; E) \qquad f(t; E^*) \longrightarrow f(0; E) \qquad (C5)$$

$$f(0; E^*) = \text{No ?} \qquad (C6)$$

"No" wa "soo iu Baai wa okoranai" to iu Imi de aru. Tatoeba (C6) no $f(0; E^*) = \text{No}$ wa "Teizyoo-Kai ga tuneni sonzaisuru" koto o imisuru. Kore ni taisite, (C5) wa "Teizyoo-Kai ka Hiteizyoo-Kai no dotiraka wa kanarazu sonzaisuru" koto o imisuru node, Okusoku tosite wa (C6) yori yowai. (C1), (C2) no Migigawa o awase-kangaeru to, " $f(t; U) = \text{No}$ " to naru. Tumari, "(teizyoo-na Kyookai-Zyookan no moto ni) Hiteizyoo-Kai ga tandokuni sonzaisuru koto wa arienai." (C3) wa, "anteina Kai ga 2-ko izyoo sonzaisuru baai, sono naka niwa anteina mono ga ari, Taylor-Uzu (kaitensuru 2-ko no Entoo no aida ni okoru) ya Karman-Uzu ga sore ni taiosuru" to iu Yosoo o noberu mono de aru.

5. Taisyoosei no aru Nagare

Kyuu ya Entyuu no mawari no Itiyoo-Ryuu no yooni, Kyookai-Zyookan ni kikagaku-tekina Taisyoosei ga aru Baai o kangaeru. Kono baai, tyokkan-tekini wa, Kai mo onazi Taisyoosei o motu to kangaerareru ga, hatasite hitaisyoo-na Kai wa sonzai dekinai no daroo ka? Ima $f(0; \text{Sym})$, $f(0; \text{Sym}^*)$ de sorezore taisyoo-teki oyobi hitaisyoo-teki na Teizyoo-Kai o arawasu koto ni siyoo. (Tatoeba, 2-ko no Kaiten-Entoo no aida no Couette no Nagare wa $f(0; \text{Sym})$ ni, Taylor-Uzu wa $f(0; \text{Sym}^*)$ ni taiosuru.) Soosureba, $R < R_{\text{sym}}$ dewa $f(0; E^*, \text{Sym}^*)$, $R > R_{\text{sym}}$ dewa $f(0; E, \text{Sym}^*)$, de aru yooni Rinkai-Reynolds-suu R_{sym} ga kangaerareyoo. Kono R_{sym} wa $f(0; U)$ no yabureru (tumari Kai no Itiisei no yabureru) Reynolds-suu R_{uni} ni mo natte iru.

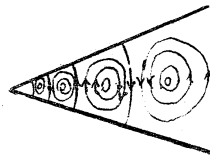
Motto ippantekini itte, 2-zigen no Nagare, ziku-taisyoo no Nagare

dewa Kuuken-Zahyoo no uti 2-ko dake ga arawareru; tumari dai-3 no Zahyoo niwa yoranai. Kyookai-Zyookken no naka ni dai-3 no Zahyoo ga arawarenai kara to itte, Kai sono mono nimo arawarenai to iu Hesyoo wa nai. Kono Zizyoo wa teizyoo-na Kyookai-Zyookken no moto ni Hiteizyoo-Kai ga sonzaisuru no to onazi de aru. Iikaereba, Teizyoo-Kai to iu no wa zikan-tekina Taisyoo-Kai de aru.

6. Kusabi-gata Ryooiki de no Nagare

Navier-Stokes Hootesiki o senkeika sita Stokes Kinzi ni oite mo, Nensei-Ryuutai no Nagare wa hukuzatuna Yoosu o simesu. Sono yoi Rei wa, Kusabi-gata Ryooiki de no Nagare de aru. Kore ni tuite wa MOFFATT no kuwasii Kenkyuu ga aru (ASC no Kaisetu o miyo!). Yooten o noberu to, Kusabi no Kaku α ga aru Rinkaiti α_1 ika dewa mugenko no Uzu no Retu ga Kusabi no Tyooten no Hukin ni arawareru to iu no de aru (Zu.2). Kono Zizyoo wa genmituna Navier-Stokes Hootesiki ni tuite mo dooyoo de aroo ka? Kantanni kangaeru to, Kabe no ue dewa Sokudo wa 0 de aru kara, Tyooten no Hukin dewa Sokudo ga tiisaku, sitagatte Stokes Kinzi ga naritatu yoo ni mo omoeru. Sikasi, Reynolds-suu ga ookiku naruto, Tyooten kara hanareta Basyo de no Nagare no Yoosu wa Stokes Kinzi kara hazure, sono Eikyoo ga "gaibu no Kyookai-Zyookken" tosite Tyooten Hukin no Nagare o sihaisuru koto mo kangaerareru kara, Zizyoo wa soo kantan de aru to wa ienai yooni omowareru.

Koko dewa kono Ten ni tuite wa tati-irazu, tada 2-zigen no Stokes Hootesiki no Ippan-Kai ni taisuru benrina Hyoosiki o ataeru ni todomeru. (IMAI 1957 o miyo!)



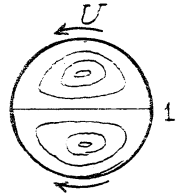
Zu. 2

$$W = u - iv, \quad z = x + iy$$

$$W = f'(z) + \overline{z} g'(z) - \overline{g(z)}, \quad f, g \text{ wa nin-i no Kaiseki-Kansuu}$$

(Rei 1) Entoo-gata no Yooki no naka no Nagare (Zu.3)

$$W = -\frac{U}{2\pi} \bar{z} \left(\log \frac{1+z}{1-z} - \log \frac{1+\bar{z}}{1-\bar{z}} + \pi i \right) + \frac{U}{\pi} \frac{z\bar{z}-1}{z^2-1}$$



(Rei 2) Kusabi-gata no Ryooki de no Nagare

$$\zeta = \pm Cz^\lambda + \bar{C}\bar{z}^\lambda$$

$$f' = (1 \mp \lambda) Cz^\lambda \pm (1 \mp \bar{\lambda}) \bar{C}\bar{z}^\lambda$$

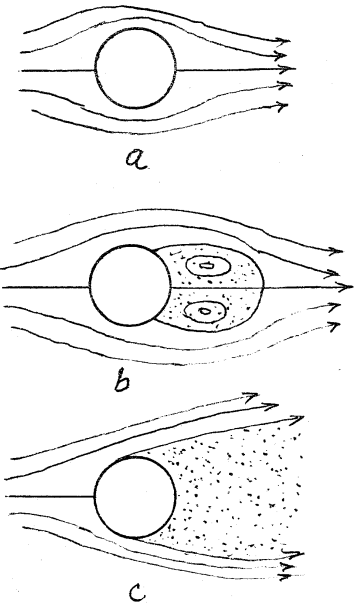
$$\frac{\sin \lambda \alpha}{\sin \alpha} = \pm \lambda$$

Zu. 3

α : Kusabi no Tyookaku, C: nin-i no Hukuso-suu, λ wa Koyuuti (ueno Hoteisiki no Kai). $\alpha < \alpha_1 = 146^\circ$ ni taisite λ wa Hukuso-suu ni naru. Kono toki mugenka no Uzu no Retu ga arawareru.

7. $R \rightarrow \infty$ ni taisuru Teizyoo-Kai

Mosimo nin-i no Reynolds-suu ni taisite Teizyoo-Kai ga sonzaisuru naraba, $R \rightarrow \infty$ ni taisite sono Kai wa dono yonna Nagare o arawasu daroo ka? Kore wa genzai mada kaiketu sarenai Mondai de aru. $R \rightarrow \infty$ wa $\mu \rightarrow 0$ ni taioosuru kara, Kanzen-Ryuutai no Nagare o arawasu koto niwa Gimon no Yoti wa nai. Sikasi, Kanzen-Ryuutai ni taisuru Helmholtz no Uzu-no-Teiri o tanzyunni tekiyoosite, uzunasino Nagare (Zu.4, a) ga Zenkin-Kai de aru to iu no wa Matigai de aru. Buttai no Hyoomen de no Kyookai-Zyookken (Sokudo = 0) ga kooryo sarete inai kara de aru. Maeni



Zu. 4

Hissya (1953) wa Zenkin-Kai wa Kirchhoff-gata no Sisui-Ryooiki o tomonau Nagare (Zu.4, c) de aroo to yosoosita. Kore ni taisite Batchelor (1956) wa, itiyoonu Uzudo no Bunpu o motu yuukaino Ryooiki o Sanryuu (Wake) to suru yoonu Nagare (Zu.4, b) o teian site iru. b-Zu no yoonu tozita Ryuusen o motu koto ga kakuzituni wakatte iru baai niwa, sono Ryuusen de kakomareta Ryooiki no naka dewa Uzudo wa tasikani ittei de aru koto ga ieru. (§8 de noberu Naibu-Mondai dewa kono Katei ga yurusereru yooni mieru. BURGERAF (1966) wa Oseen Kinzi ni nita Kaiseki-Keisan to Suuti-Keisan ni yotte kono Zizitu o urazukeru yoonu Kenkyuu o okonatte iru. Saikin, KUWABARA-Kunio (Toodai Rigakubu) mo Entoo no naka no Nagare ni tuite kuwasii Kenkyuu o site iru.) Sikasi, Buttai o sugiru itiyoonu Nagare no yoonu Gaibu-Mondai dewa, somosomo tozita Ryuusen no Sonzai sonomono ni Utagai ga aru node, Batchelor no Yosoo wa kanarazusimo tadasii to wa ienai to omowareru. Sisui no Riron kara wa Buttai no Teikoo wa $R \rightarrow \infty$ ni taisite yuugen no Atai o tori, Batchelor no Riron dewa Teikoo wa 0 ni naru. Kore wa 2-tu no Riron no mottomo itizirusii Tigai de aru. (Ookii Reynolds-suu ni taisuru N-S Hoteisiki no Suuti-Kai kara, 2-tu no Riron no dotira ga tadasii ka ni tuite Hantei ga erareru no dewa nai ka to kitai sareru.)

8. Naibu-Mondai to Gaibu-Mondai

Navier-Stokes Hoteisiki no Toriatukai ni saisite, "Naibu-Mondai" to "Gaibu-Mondai" ni wa zyuuyoonu Tigai ga aru yooni omowareru. Naibu-Mondai to wa, Yooki no naka no Ryuutai no Undoo no yooni, Nagare no Ryooiki ga yuukai no Baai o iu. Kore ni taisite, Gaibu-Mondai wa, Nagare no Ryooiki ga mugenni hirogaru Baai de atte, Buttai ni Itiyoo-Ryuu ga ataru Baai ga sono Rei de aru. Ryuutai-Rikigakusya niwa, kono Gaibu-Mondai ga tokuni zyuuyoo de aru to omowareru.

Gaibu-Mondai de tyuui sinakereba naranai no wa, Mugen-Enpoo ($r \rightarrow \infty$) de no Kyookai-Zyooken de aru. Tatoeba, Buttai ni Itiyoo-Ryuu U ga ataru baai,

$$r \rightarrow \infty \quad \text{no toki} \quad v \rightarrow U$$

o Kyookai-Zyooken to suru no ga (Ryuutai-Rikigakusya niwa) sizen de aru. Tokoroga, suugaku-teki niwa, Kai no Sonzai ya Itiisei o gironsuru baai, $v \rightarrow U$ no Tikazukikata ni tuite nanika hukatekina Katei o mookeru no ga hutuu no yoo de aru. (Tatoeba, FINN(1965)). TAKAMI no Kaisetu o miyo!) Kai no Sonzai, Itiisei ni tuite no Keturon ga kono yoonu hukatekina Katei ni yotte eikyoosareru no wa, sukunakutomo Ryuutai-Rikigakusya ni totte wa, omosiroku nai. Musiro, sono yoonu Katei o mookeru koto no Hituzensei o ataete hosii mono to omou.

Kono Ten ni tuite kangaeru beki wa, somosomo teizyoonu Itiyoo-Ryuu ga zissaitekini dono yooni site tukurareru ka to iu koto de aru. Sunawati, zissaizyoo wa, seisi-Ryuutai no naka de seisi site iru Buttai o, aru Syunkan kara ugokasi-hazimete itteino Sokudo U o motaseru yooni suru. Tumari, Hiteizyoo-Undoo no $t \rightarrow \infty$ no Kyokugen tosite erareru no ga Teizyoo-Undoo de aru. Kono Tatiba kara ieba, Ryuutai-Rikigakusya no Taisyoo to suru Teizyoo-Kai wa zitu wa Hiteizyoo-Kai no $t \rightarrow \infty$ ni taisuru Zenkin-Kai to iu koto ni naru.

Navier-Stokes Hoteisiki no suugakutekina Giron de mottomo Konnan to sareru no wa $R \rightarrow \infty$, $r \rightarrow \infty$, $t \rightarrow \infty$ no yoonu Kyokugen de no zenkintekina Hurumai de aru. Sikamo, korerano Kyokugen ga, Ryuutai-Rikigakusya ni totte wa, zitu wa mottomo Kyoomi no hukai Baai de aru koto ni tyuui sitai.

9. Suuti-Kaihoo no Konnan

Navier-Stokes Hootesiki no Kaiseki-Kai o motomeru koto wa kiwanete konnan de aru ga, saikinno Koosoku-Keisan-ki no Sinpo wa seimituna Suuti-Kai o motomeru koto o Kanoo ni sita. Sore zisin makotoni kekkoona koto dewa aru ga, dakara to itte zenmentekini Suuti-Kaihoo ni tayoreba yoi to wa ienai to omowareru. Tatoeba, $f(0; E, U)$ ga hosyoosareru naraba, nanika tekitoona Hoo-hoo de, tonikaku 1-tu Kai o motomereba sorede yoi. Sikasi, $f(0; E, U^*)$ da to suruto, 1-tu Suuti-Kai o motomete mo, zyuyyoona Kai o minogasite iru Osore ga aru. Tokuni, Reynolds-suu no ookii baai niwa sibasiba Suuti-Kai no Syuusokusei ga waruku naru koto ga keiker sareru. Kono yoona baai, Syuusokusei o yoku suru yoona Gikoo o korasite Kai o eta to site mo, sore wa aruiwa tokubetuna mono de aru ka mo sirenai. Tumari, Syuusokusei no $/:f(0; E, S^*)/$ waruku naru koto wa Kai no Huanteisei/ni kankeisuru ka mo sirezu, mata sore wa Kai no Itiisei ga yabureru koto: $f(0; E, U^*)$ ni kankeisuru ka mo sirenai kara de aru.

Sikasi, tatoe $f(0; E, U^*)$ de aru to site mo, mosimo Hiteizyoo-Kai no $t \rightarrow \infty$ ni taisuru Zenkin-Kai tosite Teizyoo-Kai ga erareta to sureba, sore koso wareware no motomeru "buturi-tekina Kai" o arawasu to ieru de aroo. Kono Imi de, $f(0; E, U)$ ga hosyoosareru kagiri, Teizyookai o motomeru Suuti-Keisanhoo tosite wa musiro Hiteizyoo-Kai no $t \rightarrow \infty$ ni taisuru Kyokugen tosite motomeru Hoosiki ga susumerareru no dewa nakaroo ka?

\$6 de nobeta Kusabi-gata Ryooiki no Nagare de mugen-ko no Uzu no Retu ga arawareru koto wa, Suuti-Kaihoo, tokuni Sabun-hoo ni yotte seimituna Kai o motomeyoo to suru baai 1-tu no Konnan o ataeru mono to omowareru. Nao, Reynolds-suu no ookii baai ni Kyookaisoo no arawareru koto mo, Sabun-hoo ni yoru Keisan o mendoo ni suru de aroo.

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