S a i na Ex an i n Sh ck f a Regula i ed B u ine S em

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[illegible]

1. Introduction

(3) 1 $u_\pm$ $h_\pm$
1 *RH locus*

$$u_\pm \quad h_\mp \left(\frac{2}{h \quad h}\right)^{1<2} \qquad (4)$$

(2) (3) 1
1 - 1 (1),

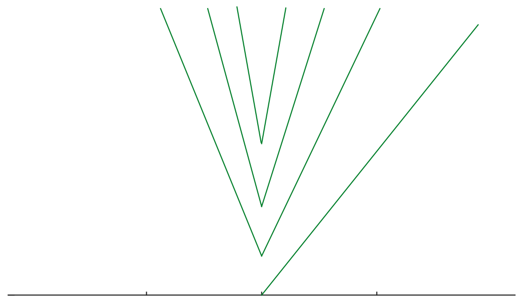
2. Expansion shock Riemann data

h_t (

1 … 1 …
1 …
1 1 … 1 …
$h_\pm$ $\frac{1}{16}(r_\pm$ $s_\pm)^2$ … (10), …
1 … (14) … (15). … 1
$s_\pm$, $r_\pm$ … 1 … H 1, 1 1 …
A … H 1 … 1 … 11 …
… (10) …
1 … 1 …
… 5.

3. BBM approximation and the structure of the expansion shock

1 …
(11) 1 … 11 … 1 …
1 …



4. Expansion shock for the Boussinesq equations

4.1. Inner solution: first-order approximation

$$r^{(\cdot)} \quad \frac{1}{4\delta}(3r^{(\cdot)} \quad s^{(\cdot)})r^{(\cdot)} \quad \frac{}{6\delta^2}\left(r^{(\cdot)} \quad s^{(\cdot)}\right)$$

$$s^{(\cdot)}$$

$r^{(0)}, r^{(1)}, r^{(2)}, s^{(0)}$, $s^{(2)}$ (1) $\to 0$, $\delta \to 0$, $\to 0$.
1 1 1 1 r (15),
1 s $s^{(1)}$ 0,
1 ,
.
1 (21) (20),

$$\left(r^{(1)} \quad \cdots\right)$$

$$\frac{1}{4\delta}\left(3r^{(0)} \quad s^{(0)} \quad 3r^{(1)} \quad ^2(3r^{(2)} \quad s^{(2)}) \quad \cdots\right)\left(r^{(1)} \quad ^2 r^{(2)} \quad \cdots\right)$$

$$\overline{6\delta^2}\left(r^{(1)} \quad ^2\left(r^{(2)} \quad s^{(2)}\right) \quad \cdots\right) \tag{22}$$

$$\left(\, ^2 s^{(2)} \quad \cdots\right) \quad \frac{1}{4\delta}\left(r^{(0)} \quad 3s^{(0)} \quad \cdots\right)\left(^2 s^{(2)} \quad \cdots\right)$$
$$\overline{6\delta^2}\left(r^{(1)} \quad \cdots\right). \tag{23}$$

B $\ll 1/\delta$, (22)

$$\left(\frac{}{\delta}\right): \quad \frac{1}{}$$

$$\frac{2a}{9a^2} \quad \frac{ff'}{f''} \quad K. \tag{30}$$

K / 0 1 . a f BB
5

$$a(\ ) \quad \frac{A}{\frac{9}{2}AK \quad 1}. \quad f(\ ) \quad B \left(\frac{B}{2K}\right. \quad . \tag{31}$$

A / 0 B / 0 1
1

$$B \quad 1. \quad K \quad \frac{1}{2}. \tag{32}$$

1 , 1 A,
, (31)

$$a(\ ) \quad \frac{A}{\frac{9}{4}A \quad 1}. \quad f(\ ) \quad (\ ) \tag{33}$$

, 1 1

$$r^{(\ )}(\ .\ ) \quad \frac{s^{(0)}}{3} \quad \frac{A}{\frac{9}{4}A \quad 1} (\ ) \quad (^2). \tag{34}$$

$$s^{(\ )}(\ .\ ) \quad s^{(0)} \quad (^2). \tag{35}$$

1 $s^{(0)}$ A
, (34), (35) 0, → , 1
, 1 1 (12)
1 :

$$r_{\pm} \quad \frac{s^{(0)}}{3} \pm A \quad (^2). \tag{36}$$

$s_{\pm}$

$> _t \gg _x$ 0, $>$ $\frac{1}{4}(s^{(0)}$ $3r)$ ((19)).
1 BB (18). ,
$>$
BB 1 5 .

E … 11 …

… 1 …

$$r^{(\,)}(\;.\;) \sim 1 \quad \left(\frac{1}{4} \quad \frac{(\;)}{1 \quad \frac{9}{4}} \right)$$

$$\frac{\;^2}{3}\left(C \quad \frac{2 \quad 17 \quad ^2(\;) \quad D\,(\;) \quad E \quad (\;)}{16\left(1 \quad \frac{9}{4}\right)^2} \right).$$

$$s^{(\,)}(\;.\;) \sim 3 \quad \frac{3}{4} \quad ^2 \Big(C \quad \frac{3 \quad ^2(\;)}{16\left(1 \quad ^9\right.}$$

$$\epsilon r^{(\,)} \quad \frac{1}{4}(3r^{(\,)} \quad s^{(\,)})r_X^{(\,)} \quad 0.$$
$$\epsilon s^{(\,)} \quad \frac{1}{4}(r^{(\,)} \quad 3s^{(\,)})s_X^{(\,)} \quad 0 \qquad (51)$$

1 1 , 1

$$s^{(\,)}(X. \;) \quad 3 \quad \frac{3}{4}\epsilon \quad \frac{1}{32}\epsilon^2 \quad \cdots.$$
$$r^{(\,)}(X. \;) \quad 1 \quad \epsilon\left(\frac{1}{4} \quad r_1(X. \;) \right. \quad \epsilon^2\left(\frac{1}{96} \quad r_2(X. \;) \right. \quad \cdots \qquad (52)$$

1 , (5) $s^{(\,)}$.
$r^{(\,)}$, 1 1 ϵ,

$$(\epsilon^2): \quad r_{1.} \quad \frac{3}{4}r_1 r_{1.X} \quad 0. \qquad (53)$$

10.95892.701 2.031441.804 (.( )20.1( )0.2( )-330.8( )-330.8( )-331(

(58). (50),

$$\lim_{X\to 0^{\pm}} r_2(X,\ ) \quad F_2^{\pm}\frac{1}{\left(1 \quad \frac{9}{4}\ \right)^2} \qquad \to\pm \quad r^{(2)}(\ \cdot\ ) \quad \frac{1}{24\left(1 \quad \frac{9}{4}\ \right)^2}. \tag{60}$$

F_2 F_2 1<24,

$$r_2(X,\ ) \quad \frac{1 \quad 3\ X}{24\left(1 \quad \frac{9}{4}\ \right)^2} \tag{61}$$

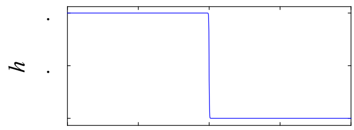
11

$$r^{(\ )}(X,\ ) \quad 1 \quad \left(\frac{1}{4} \quad \frac{X \quad 3X}{1 \quad \frac{9}{4}} \right)$$

$$\frac{\ ^2}{24}\left(\frac{1}{4} \quad 1 \quad 3 \right.$$

, , 1 1 , 1

$r^{(\ )}(X. \ ) \quad 1$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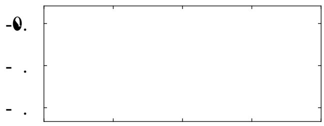

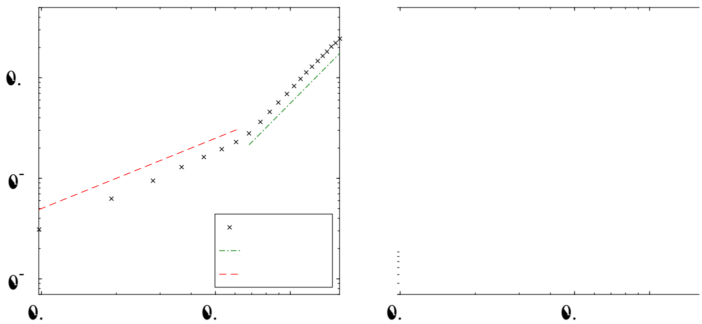

6. Discussion

Acknowledgments

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Appendix

A 1 1 1 11 . L. L x_n L $2Ln/N$, n 0. . . . . N 1. 1 h u, 1 g h_x, u_x

$$g_t \quad (ug)_x \quad (h\ )_x \quad 0.$$

$$\ _t \quad (u\ )_x \quad g_x \quad \frac{1}{3}\ _{xxt} \quad 0 \tag{A1}$$

B L $h(\pm L.\, t)$ $h_\pm$ $u(\pm L.\, t)$ $u_\pm$ 10^{9} g 1 . (A1) 1 1 1 1 1 1 ,

$$(ug)_{x\ n} \quad ik_n\ ug\ _n. \quad n \quad N/2. \cdots . N/2 \quad 1. \tag{A2}$$

1 1 - k_n $n\ L$ h 11 g

$$h(x_n.\, t) \quad h \quad ^{1}\ g(t)\ _n \quad \frac{1}{2L}(h \quad h\ )(x_n \quad L). \tag{A3}$$

$$g_n(t) \quad \begin{cases} \dfrac{2L}{N} \displaystyle\sum_{m \quad N/2}^{N/2 \quad 1} x_m g(x_m.\, t) & n \quad 0 \\ \dfrac{g_n(t)}{ik_n} & n \quad 0 \end{cases} \tag{A4}$$

n 0 (A4) 1 11 $\int_{L}^{L} xg(x.\, t)dx$, h g . A 1 1 u.

1 1

1 (A1)

1 0.002 t 45. L 120 (

2 3 1

N 2^{14}. 1