Escoamento compressível em bocais
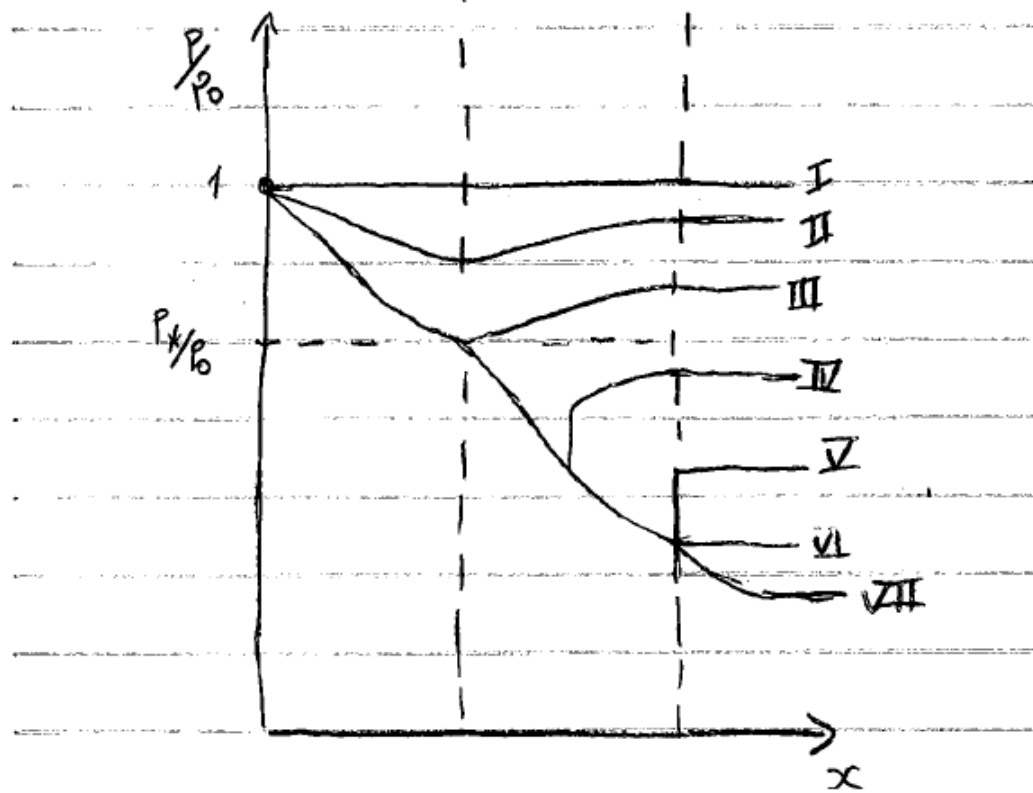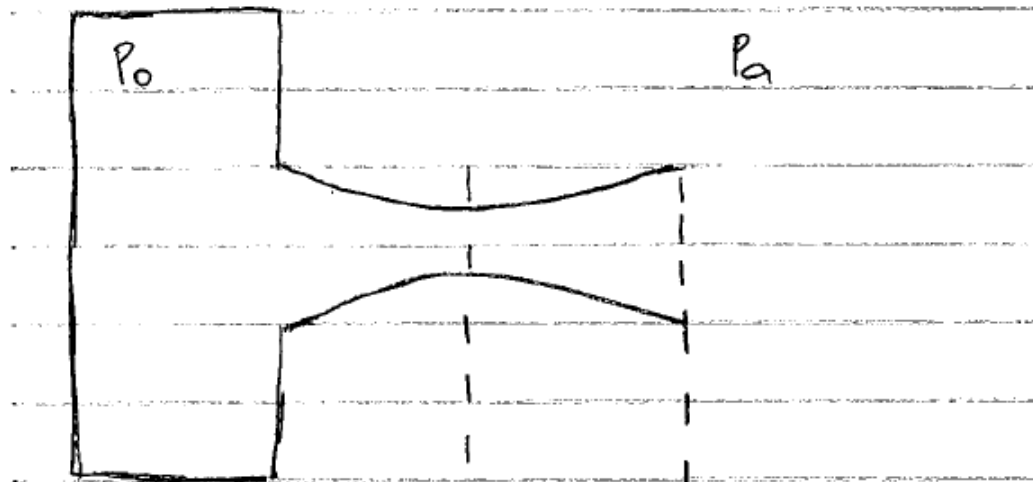
Bocais convergente/divergents

- Conhecido como bocal de Laval
- Quando não houver choque no duto:
  - Equações para escoamento isentrópico
- Quando houver choque no duto
  - Equações com Δs diferente de zero

Holographic interferogram of high-speed flow through a Laval nozzle. Image made at the Penn State Gas dynamics Laboratory.
http://www.me.psu.edu/psgdl/
http://media.efluids.com/galleries/compressible?medium=553

P_0

P_a

$\dfrac{P}{P_0}$

1

P_*/P_0

I

II

III

IV

V

VI

VII

x

Continuando com relações para esc. compr.

- Definição:

- $M_* = \dfrac{V}{a_*} = \dfrac{V}{V_*}$

- Mais algumas relações isentrópicas (sem choque):

- $M_* = \dfrac{\frac{\gamma+1}{2}M^2}{1+\frac{\gamma-1}{2}M^2}$

- $\dfrac{A_*}{A} = \left(1 + \dfrac{\gamma-1}{2}M^2\right)^{-1/\gamma-1} \left(\dfrac{2}{\gamma+1}\right)^{-1/\gamma-1} \left(\dfrac{\frac{\gamma+1}{2}M^2}{1+\frac{\gamma-1}{2}M^2}\right)^{1/2}$

M	T/t	P/p	V/root(T)	m root(T)/AP	m root(T)/Ap	A/A*
0,260	1,0135	1,0481	5,1768	0,0174	0,0183	2,3173
0,265	1,0140	1,0500	5,2750	0,0177	0,0186	2,2771
0,270	1,0146	1,0520	5,3731	0,0181	0,0190	2,2385
0,275	1,0151	1,0539	5,4711	0,0184	0,0194	2,2013
0,280	1,0157	1,0560	5,5691	0,0187	0,0197	2,1656
0,285	1,0162	1,0580	5,6670	0,0190	0,0201	2,1311
0,290	1,0168	1,0601	5,7648	0,0193	0,0204	2,0979
0,295	1,0174	1,0623	5,8625	0,0196	0,0208	2,0659
0,300	1,0180	1,0644	5,9601	0,0199	0,0211	2,0351
0,305	1,0186	1,0666	6,0576	0,0202	0,0215	2,0053
0,310	1,0192	1,0689	6,1551	0,0204	0,0219	1,9765
0,315	1,0198	1,0712	6,2524	0,0207	0,0222	1,9487
0,320	1,0205	1,0735	6,3497	0,0210	0,0226	1,9219
0,325	1,0211	1,0759	6,4469	0,0213	0,0229	1,8959
0,330	1,0218	1,0783	6,5440	0,0216	0,0233	1,8707
0,335	1,0224	1,0808	6,6409	0,0219	0,0237	1,8464
0,340	1,0231	1,0833	6,7378	0,0222	0,0240	1,8229
0,345	1,0238	1,0858	6,8346	0,0225	0,0244	1,8001
0,350	1,0245	1,0884	6,9313	0,0227	0,0247	1,7780
0,355	1,0252	1,0910	7,0279	0,0230	0,0251	1,7565
0,360	1,0259	1,0937	7,1244	0,0233	0,0255	1,7358
0,365	1,0266	1,0964	7,2208	0,0236	0,0258	1,7156
0,370	1,0274	1,0992	7,3171	0,0238	0,0262	1,6961

M	T/t	P/p	V/root(T)	m root(T)/AP	m root(T)/Ap	A/A*
0,520	1,0541	1,2024	10,1525	0,0310	0,0373	1,3034
0,525	1,0551	1,2066	10,2450	0,0312	0,0377	1,2948
0,530	1,0562	1,2108	10,3374	0,0314	0,0380	1,2865
0,535	1,0572	1,2151	10,4297	0,0316	0,0384	1,2783
0,540	1,0583	1,2194	10,5218	0,0318	0,0388	1,2703
0,545	1,0594	1,2238	10,6138	0,0320	0,0392	1,2625
0,550	1,0605	1,2283	10,7056	0,0322	0,0396	1,2549
0,555	1,0616	1,2327	10,7973	0,0324	0,0399	1,2475
0,560	1,0627	1,2373	10,8889	0,0326	0,0403	1,2403
0,565	1,0638	1,2419	10,9803	0,0328	0,0407	1,2332
0,570	1,0650	1,2465	11,0716	0,0330	0,0411	1,2263
0,575	1,0661	1,2512	11,1627	0,0331	0,0415	1,2196
0,580	1,0673	1,2560	11,2537	0,0333	0,0418	1,2130
0,585	1,0684	1,2608	11,3445	0,0335	0,0422	1,2066
0,590	1,0696	1,2656	11,4352	0,0337	0,0426	1,2003
0,595	1,0708	1,2705	11,5257	0,0338	0,0430	1,1942
0,600	1,0720	1,2755	11,6161	0,0340	0,0434	1,1882
0,605	1,0732	1,2805	11,7063	0,0342	0,0438	1,1824
0,610	1,0744	1,2856	11,7964	0,0344	0,0442	1,1767
0,615	1,0756	1,2907	11,8863	0,0345	0,0445	1,1711
0,620	1,0769	1,2959	11,9760	0,0347	0,0449	1,1656
0,625	1,0781	1,3012	12,0656	0,0348	0,0453	1,1603
0,630	1,0794	1,3065	12,1551	0,0350	0,0457	1,1552
0,635	1,0806	1,3119	12,2444	0,0351	0,0461	1,1501
0,640	1,0819	1,3173	12,3335	0,0353	0,0465	1,1451
0,645	1,0832	1,3228	12,4225	0,0354	0,0469	1,1403

M	T/t	P/p	V/root(T)	m root(T)/AP	m root(T)/Ap	A/A*
1,690	1,5712	4,8622	27,0255	0,0304	0,1480	1,3283
1,695	1,5746	4,8989	27,0763	0,0303	0,1486	1,3329
1,700	1,5780	4,9360	27,1269	0,0302	0,1492	1,3376
1,705	1,5814	4,9734	27,1774	0,0301	0,1498	1,3423
1,710	1,5848	5,0111	27,2277	0,0300	0,1504	1,3471
1,715	1,5882	5,0491	27,2779	0,0299	0,1510	1,3519
1,720	1,5917	5,0874	27,3279	0,0298	0,1516	1,3567
1,725	1,5951	5,1260	27,3777	0,0297	0,1522	1,3616
1,730	1,5986	5,1650	27,4274	0,0296	0,1528	1,3665
1,735	1,6020	5,2043	27,4769	0,0295	0,1534	1,3715
1,740	1,6055	5,2439	27,5262	0,0294	0,1540	1,3764
1,745	1,6090	5,2839	27,5754	0,0293	0,1546	1,3814
1,750	1,6125	5,3241	27,6244	0,0292	0,1552	1,3865
1,755	1,6160	5,3647	27,6733	0,0290	0,1558	1,3916
1,760	1,6195	5,4057	27,7220	0,0289	0,1564	1,3967
1,765	1,6230	5,4470	27,7705	0,0288	0,1570	1,4019
1,770	1,6266	5,4886	27,8189	0,0287	0,1577	1,4070
1,775	1,6301	5,5306	27,8672	0,0286	0,1583	1,4123
1,780	1,6337	5,5729	27,9152	0,0285	0,1589	1,4175
1,785	1,6372	5,6156	27,9632	0,0284	0,1595	1,4228
1,790	1,6408	5,6587	28,0109	0,0283	0,1601	1,4282
1,795	1,6444	5,7020	28,0585	0,0282	0,1608	1,4336
1,800	1,6480	5,7458	28,1060	0,0281	0,1614	1,4390

| M	T/t	P/p	V/root(T)	m root(T)/AP	m root(T)/Ap	A/A*
1,950	1,7605	7,2398	29,4592	0,0250	0,1807	1,6193
1,955	1,7644	7,2962	29,5021	0,0249	0,1814	1,6259
1,960	1,7683	7,3530	29,5448	0,0248	0,1820	1,6326
1,965	1,7722	7,4103	29,5873	0,0247	0,1827	1,6393
1,970	1,7762	7,4680	29,6297	0,0246	0,1834	1,6461
1,975	1,7801	7,5262	29,6720	0,0245	0,1840	1,6529
1,980	1,7841	7,5849	29,7141	0,0244	0,1847	1,6597
1,985	1,7880	7,6441	29,7561	0,0243	0,1854	1,6666
1,990	1,7920	7,7037	29,7980	0,0242	0,1861	1,6735
1,995	1,7960	7,7638	29,8397	0,0241	0,1867	1,6805
2,000	1,8000	7,8244	29,8812	0,0240	0,1874	1,6875
2,005	1,8040	7,8856	29,9227	0,0239	0,1881	1,6946
2,010	1,8080	7,9471	29,9640	0,0238	0,1888	1,7016
2,015	1,8120	8,0092	30,0051	0,0237	0,1894	1,7088
2,020	1,8161	8,0718	30,0462	0,0236	0,1901	1,7160
2,025	1,8201	8,1349	30,0870	0,0235	0,1908	1,7232
2,030	1,8242	8,1985	30,1278	0,0234	0,1915	1,7305
2,035	1,8282	8,2627	30,1684	0,0233	0,1922	1,7378
2,040	1,8323	8,3273	30,2089	0,0232	0,1929	1,7451
2,045	1,8364	8,3925	30,2492	0,0231	0,1936	1,7525
2,050	1,8405	8,4581	30,2894	0,0230	0,1942	1,7600
2,055	1,8446	8,5244	30,3295	0,0229	0,1949	1,7675

Logo, para o bocal conv/div

- Se $P_{III} < P_s < P_{VI}$
  - Ondas de choque no interior do bocal.
- Conhecidas cond. Antes do choque => cond. Depois do choque
- No choque, esc. não é isentrópico!

Choque
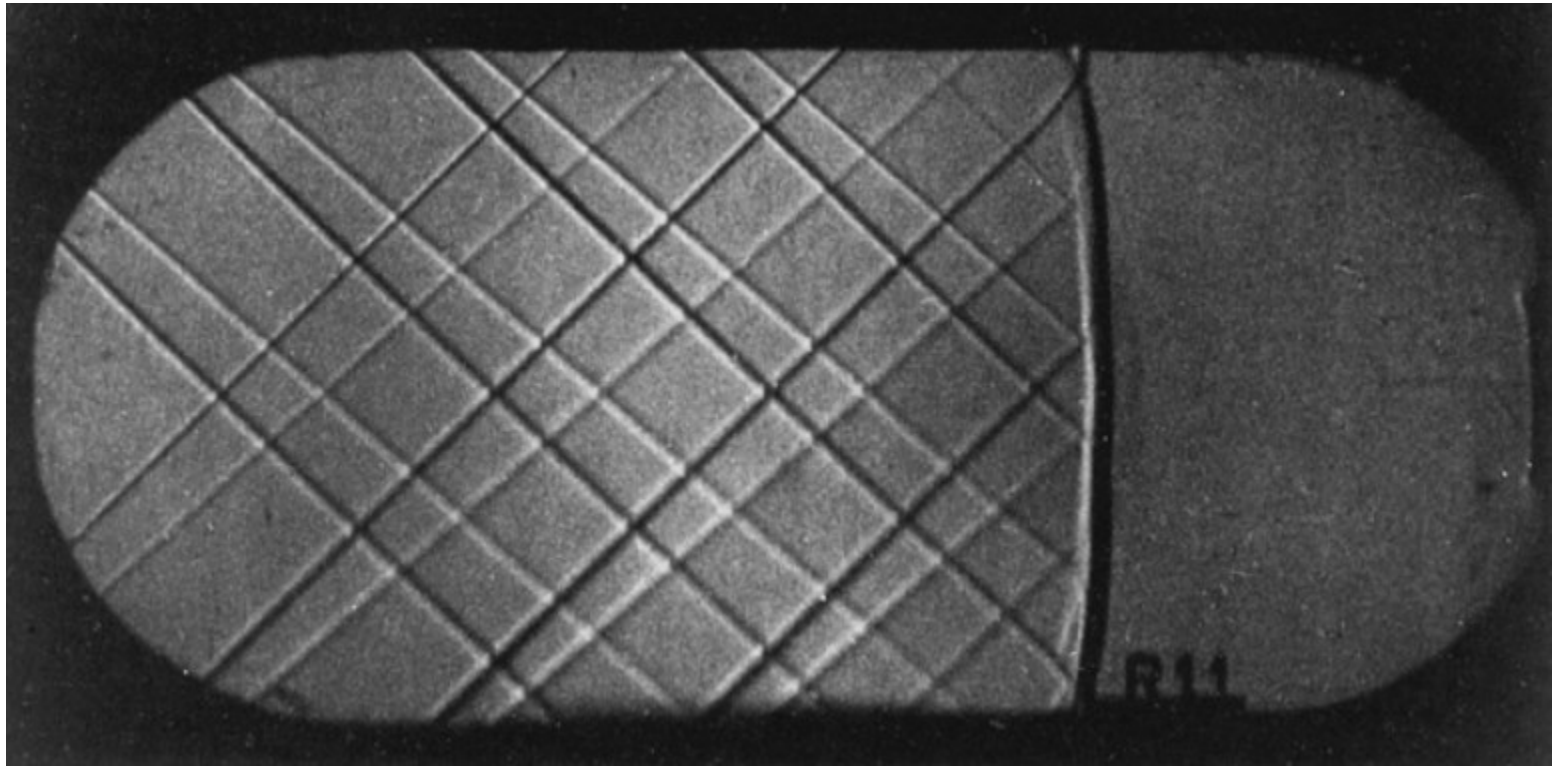
Choque
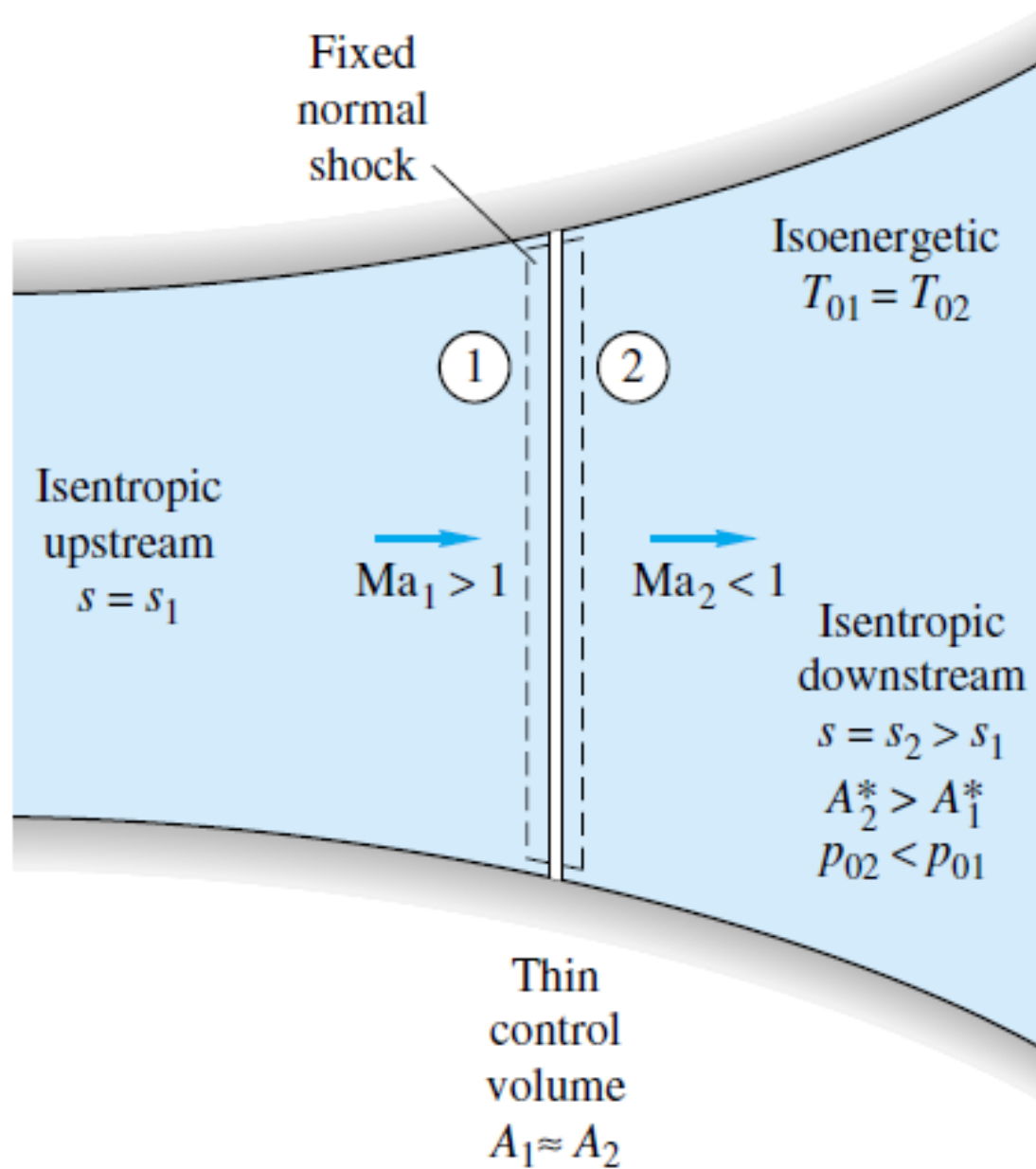
Choque normal

- Massa $$\rho_1 V_1 = \rho_2 V_2 = G = \text{const}$$

- QDM $$p_1 - p_2 = \rho_2 V_2^2 - \rho_1 V_1^2$$

- Energia $$h_1 + \tfrac{1}{2}V_1^2 = h_2 + \tfrac{1}{2}V_2^2 = h_0 = \text{const}$$

- Gás Perf. $$\frac{p_1}{\rho_1 T_1} = \frac{p_2}{\rho_2 T_2}$$

onde 1 = a montante do choque e 2 = a jusante do choque

Desenvolvendo estas eqs...

$$\frac{p_2}{p_1} = \frac{1}{k+1} \left[2k \, \mathrm{Ma}_1^2 - (k-1) \right]$$

$$\mathrm{Ma}_2^2 = \frac{(k-1)\,\mathrm{Ma}_1^2 + 2}{2k\,\mathrm{Ma}_1^2 - (k-1)}$$

$$\frac{\rho_2}{\rho_1} = \frac{(k+1)\,\mathrm{Ma}_1^2}{(k-1)\,\mathrm{Ma}_1^2 + 2} = \frac{V_1}{V_2}$$

$$\frac{T_2}{T_1} = \left[2 + (k-1)\,\mathrm{Ma}_1^2 \right] \frac{2k\,\mathrm{Ma}_1^2 - (k-1)}{(k+1)^2\,\mathrm{Ma}_1^2}$$

$$T_{02} = T_{01}$$

$$\frac{p_{02}}{p_{01}} = \frac{\rho_{02}}{\rho_{01}} = \left[\frac{(k+1)\,\mathrm{Ma}_1^2}{2 + (k-1)\,\mathrm{Ma}_1^2} \right]^{k/(k-1)} \left[\frac{k+1}{2k\,\mathrm{Ma}_1^2 - (k-1)} \right]^{1/(k-1)}$$
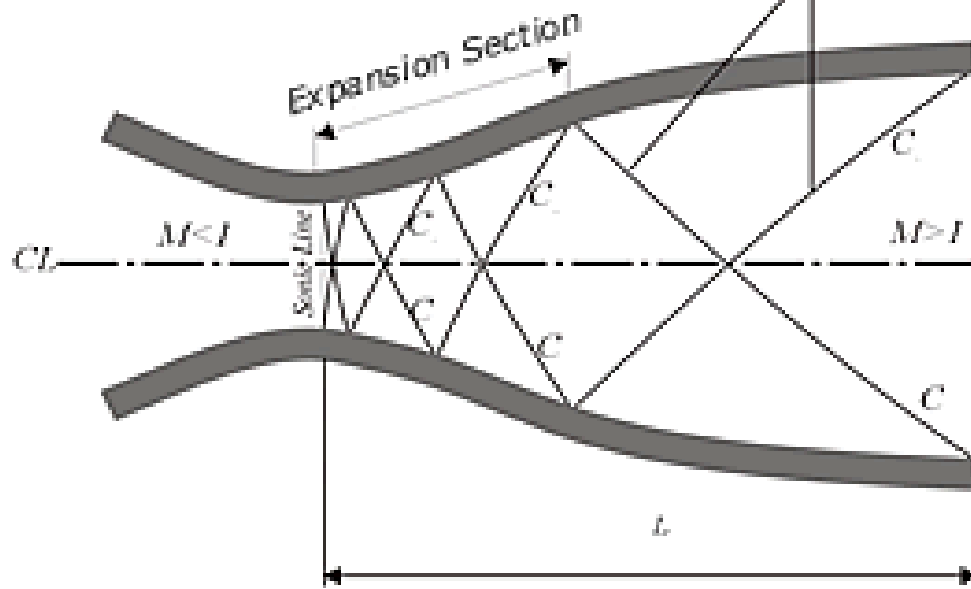
Choque normal

- Em suma, conhecendo-se as condições antes do choque, podemos calcular as condições logo após o choque

- Estes cálculos já foram feitos e se encontram na forma de tabelas

M1	Pt1/P1	Tt1/T1	M2	P2/P1	T2/T1	ρ2/ρ1	Pt2/P2	Pt2/Pt1
1,600	4,2504	1,5120	0,6684	2,8200	1,3880	2,0317	1,3493	0,8952
1,605	4,2820	1,5152	0,6669	2,8387	1,3914	2,0401	1,3475	0,8933
1,610	4,3139	1,5184	0,6655	2,8574	1,3949	2,0485	1,3458	0,8915
1,615	4,3461	1,5216	0,6640	2,8763	1,3983	2,0569	1,3441	0,8896
1,620	4,3785	1,5249	0,6625	2,8951	1,4018	2,0653	1,3425	0,8877
1,625	4,4112	1,5281	0,6611	2,9141	1,4053	2,0736	1,3408	0,8857
1,630	4,4442	1,5314	0,6596	2,9330	1,4088	2,0820	1,3392	0,8838
1,635	4,4774	1,5346	0,6582	2,9521	1,4123	2,0903	1,3375	0,8819
1,640	4,5110	1,5379	0,6568	2,9712	1,4158	2,0986	1,3359	0,8799
1,645	4,5448	1,5412	0,6554	2,9904	1,4193	2,1069	1,3343	0,8780
1,650	4,5789	1,5445	0,6540	3,0096	1,4228	2,1152	1,3328	0,8760
1,655	4,6132	1,5478	0,6526	3,0289	1,4263	2,1235	1,3312	0,8740
1,660	4,6479	1,5511	0,6512	3,0482	1,4299	2,1318	1,3297	0,8720
1,665	4,6829	1,5544	0,6498	3,0676	1,4334	2,1401	1,3281	0,8700
1,670	4,7181	1,5578	0,6485	3,0870	1,4369	2,1484	1,3266	0,8680
1,675	4,7537	1,5611	0,6471	3,1066	1,4405	2,1566	1,3251	0,8660
1,680	4,7896	1,5645	0,6458	3,1261	1,4440	2,1649	1,3236	0,8639
1,685	4,8257	1,5678	0,6445	3,1458	1,4476	2,1731	1,3222	0,8619
1,690	4,8622	1,5712	0,6431	3,1654	1,4512	2,1813	1,3207	0,8599
1,695	4,8989	1,5746	0,6418	3,1852	1,4547	2,1895	1,3193	0,8578
1,700	4,9360	1,5780	0,6405	3,2050	1,4583	2,1977	1,3179	0,8557
1,705	4,9734	1,5814	0,6393	3,2249	1,4619	2,2059	1,3165	0,8536
1,710	5,0111	1,5848	0,6380	3,2448	1,4655	2,2141	1,3151	0,8516
1,715	5,0491	1,5882	0,6367	3,2648	1,4691	2,2222	1,3137	0,8495
1,720	5,0874	1,5917	0,6355	3,2848	1,4727	2,2304	1,3124	0,8474

Ma_{n1}	Ma_{n2}	p_2/p_1	$V_1/V_2 = \rho_2/\rho_1$	T_2/T_1	p_{02}/p_{01}	A_2^*/A_1^*
1.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.10	0.9118	1.2450	1.1691	1.0649	0.9989	1.0011
1.20	0.8422	1.5133	1.3416	1.1280	0.9928	1.0073
1.30	0.7860	1.8050	1.5157	1.1909	0.9794	1.0211
1.40	0.7397	2.1200	1.6897	1.2547	0.9582	1.0436
1.50	0.7011	2.4583	1.8621	1.3202	0.9298	1.0755
1.60	0.6684	2.8200	2.0317	1.3880	0.8952	1.1171
1.70	0.6405	3.2050	2.1977	1.4583	0.8557	1.1686
1.80	0.6165	3.6133	2.3592	1.5316	0.8127	1.2305
1.90	0.5956	4.0450	2.5157	1.6079	0.7674	1.3032
2.00	0.5774	4.5000	2.6667	1.6875	0.7209	1.3872
2.10	0.5613	4.9783	2.8119	1.7705	0.6742	1.4832
2.20	0.5471	5.4800	2.9512	1.8569	0.6281	1.5920
2.30	0.5344	6.0050	3.0845	1.9468	0.5833	1.7144
2.40	0.5231	6.5533	3.2119	2.0403	0.5401	1.8514
2.50	0.5130	7.1250	3.3333	2.1375	0.4990	2.0039
2.60	0.5039	7.7200	3.4490	2.2383	0.4601	2.1733
2.70	0.4956	8.3383	3.5590	2.3429	0.4236	2.3608
2.80	0.4882	8.9800	3.6636	2.4512	0.3895	2.5676
2.90	0.4814	9.6450	3.7629	2.5632	0.3577	2.7954

Linhas de Mach
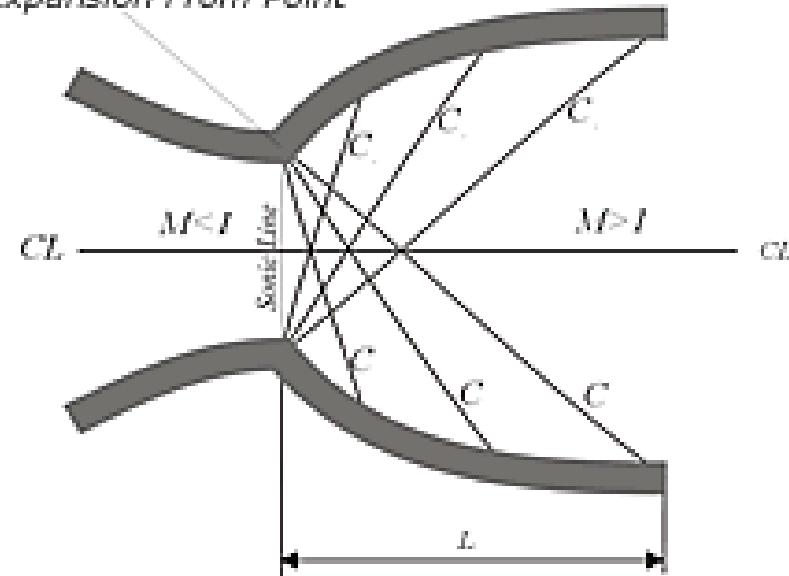
UNIVERSITY OF LIVERPOOL

http://www.liv.ac.uk/researchintelligence/issue13/macro.html
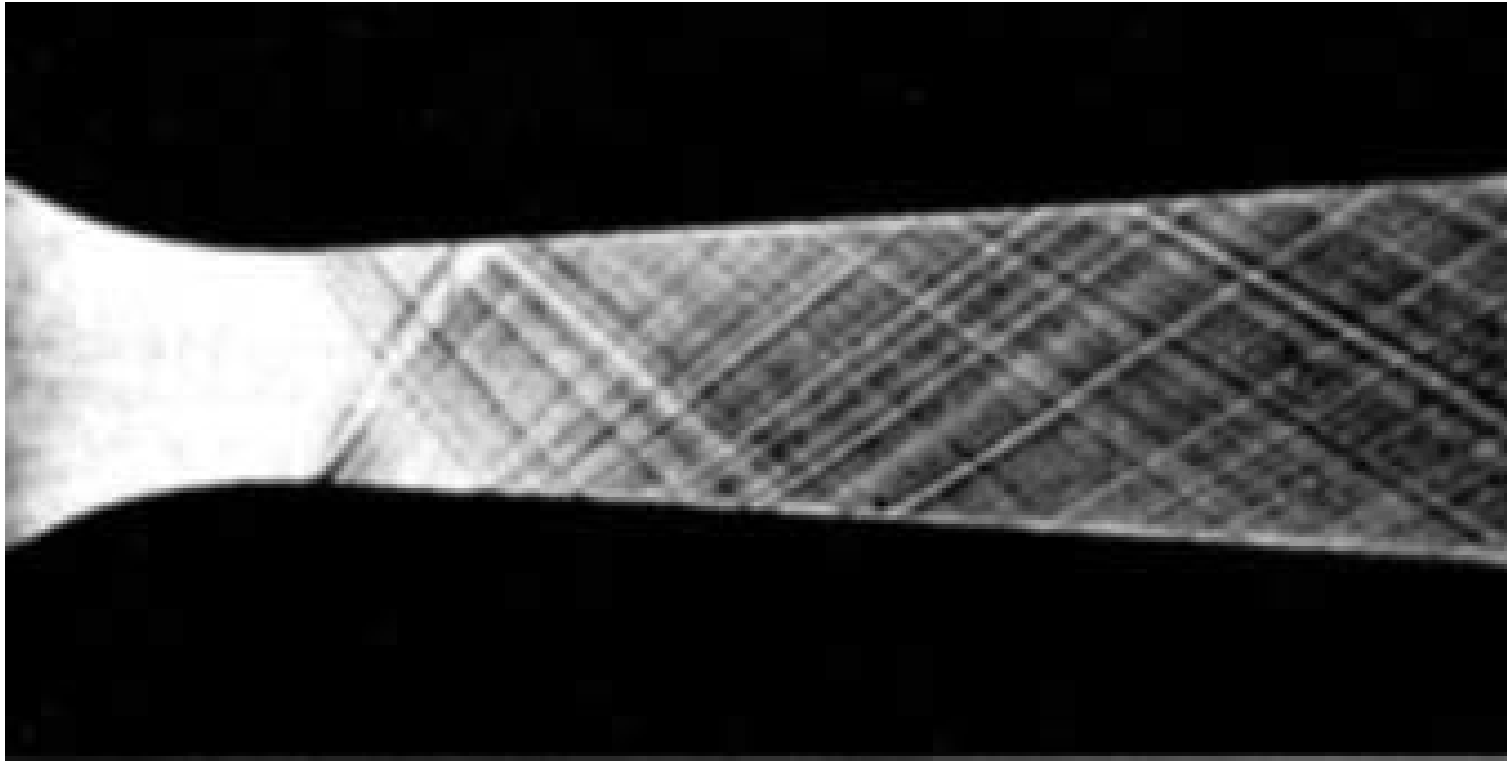
PENN STATE
COLLEGE OF ENGINEERING MECHANICAL & NUCLEAR ENGINEERING
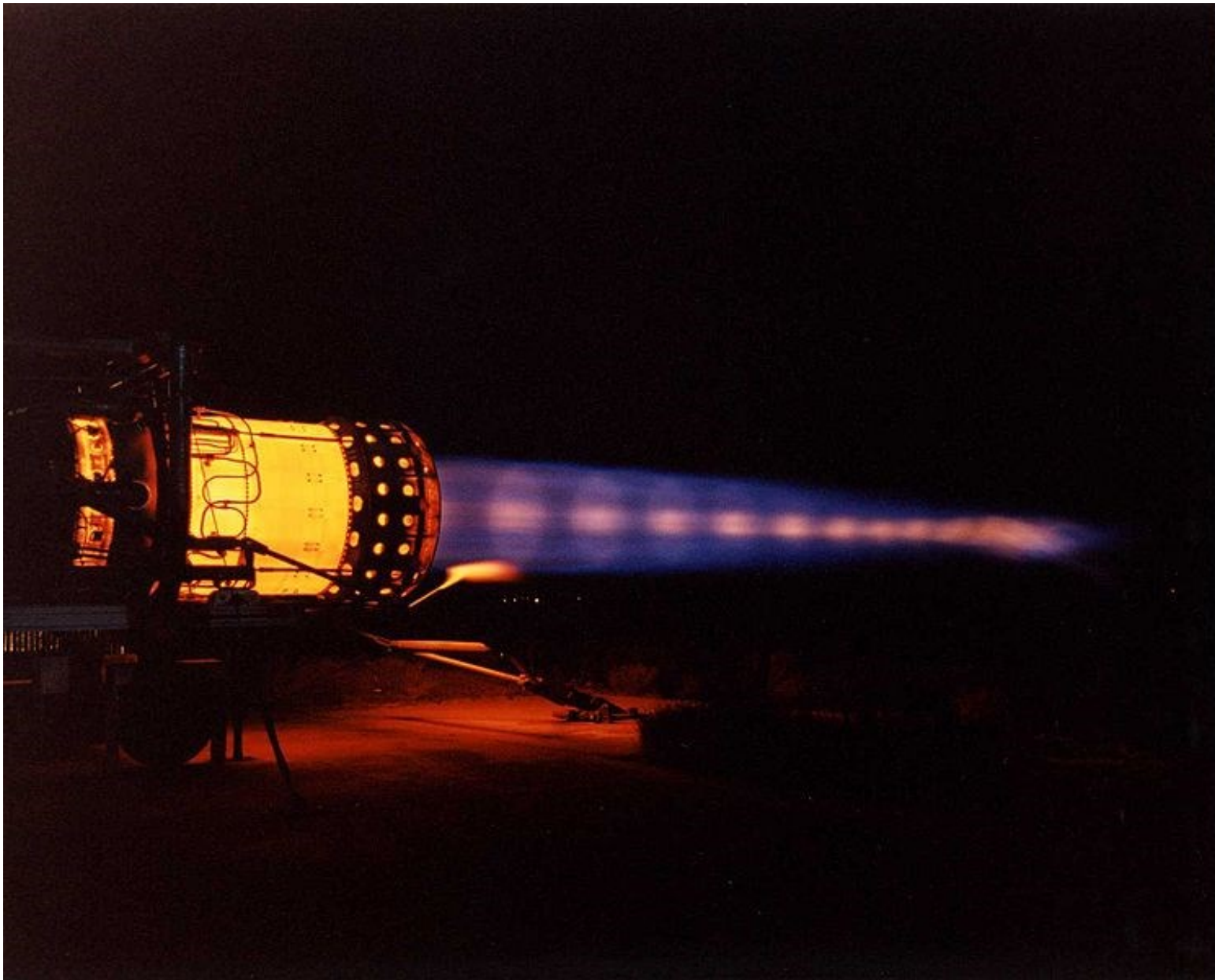http://www.mne.psu.edu/psgdl/Courses.html

SR-71 (Lockheed)
http://en.wikipedia.org/wiki/File:SR-71_Blackbird_afterburn.jpg

F-16 (Lockheed)
http://en.wikipedia.org/wiki/File:South_Carolina_F-16_taking_off_in_Afghanistan.jpg

J-58 (Pratt & Whitney)

Exercício

- Um duto convergente-divergente possui as seguintes condições de estagnação: Temperatura = 500K e Pressão = 10^6Pa. A área da garganta vale 0,01 m^2 e o número de Mach na saída é 2,0. (a) Determine a vazão de ar. (b) Determine a área e a temperatura na saída.

Exercício

- Ar em um tanque a 2.10^5 Pa se expande em um duto convergente-divergente com área da garganta = 15cm^2 e área de saída = 30cm^2. Na parte divergente, em A=20cm^2 há uma onda de choque. Calcule a pressão na saída.

Exercício

- Uma turbina a gás possui um duto de escape na forma de um bocal convergente/divergente com área de saída A_s=28cm^2. Considere as condições de estagnação na entrada do bocal P_0=10^{6}Pa e T_0 = 500K. Pede-se:

a. Se a pressão na saída for P_s=2,5.10^{5}Pa, determine a área da garganta para que não haja choque no bocal.

b. Se a pressão na saída for P_s=9,84.10^{5}Pa (com a mesma área de garganta calculada anteriormente), haverá choque dentro do bocal? Justifique.

Ma	p/p_0	ρ/ρ_0	T/T_0	A/A^*
0,0	1,0	1,0	1,0	∞
0,02	0,9997	0,9998	0,9999	28,9421
0,04	0,9989	0,9992	0,9997	14,4815
0,06	0,9975	0,9982	0,9993	9,6659
0,08	0,9955	0,9968	0,9987	7,2616
0,1	0,9930	0,9950	0,9980	5,8218
0,12	0,9900	0,9928	0,9971	4,8643
0,14	0,9864	0,9903	0,9961	4,1824
0,16	0,9823	0,9873	0,9949	3,6727
0,18	0,9776	0,9840	0,9936	3,2779
0,2	0,9725	0,9803	0,9921	2,9635
0,22	0,9668	0,9762	0,9904	2,7076
0,24	0,9607	0,9718	0,9886	2,4956
0,26	0,9541	0,9670	0,9867	2,3173
0,28	0,9470	0,9619	0,9846	2,1656
0,3	0,9395	0,9564	0,9823	2,0351
0,32	0,9315	0,9506	0,9799	1,9219
0,34	0,9231	0,9445	0,9774	1,8229
0,36	0,9143	0,9380	0,9747	1,7358
0,38	0,9052	0,9313	0,9719	1,6587
0,4	0,8956	0,9243	0,9690	1,5901
0,42	0,8857	0,9170	0,9659	1,5289
0,44	0,8755	0,9094	0,9627	1,4740
0,46	0,8650	0,9016	0,9594	1,4246
0,48	0,8541	0,8935	0,9559	1,3801
0,5	0,8430	0,8852	0,9524	1,3398
0,52	0,8317	0,8766	0,9487	1,3034
0,54	0,8201	0,8679	0,9449	1,2703
0,56	0,8082	0,8589	0,9410	1,2403
0,58	0,7962	0,8498	0,9370	1,2130
0,6	0,7840	0,8405	0,9328	1,1882
0,62	0,7716	0,8310	0,9286	1,1656
0,64	0,7591	0,8213	0,9243	1,1451
0,66	0,7465	0,8115	0,9199	1,1265
0,68	0,7338	0,8016	0,9153	1,1097
0,7	0,7209	0,7916	0,9107	1,0944
0,72	0,7080	0,7814	0,9061	1,0806
0,74	0,6951	0,7712	0,9013	1,0681
0,76	0,6821	0,7609	0,8964	1,0570
0,78	0,6690	0,7505	0,8915	1,0471
0,8	0,6560	0,7400	0,8865	1,0382
0,82	0,6430	0,7295	0,8815	1,0305
0,84	0,6300	0,7189	0,8763	1,0237
0,86	0,6170	0,7083	0,8711	1,0179
0,88	0,6041	0,6977	0,8659	1,0129
0,9	0,5913	0,6870	0,8606	1,0089
0,92	0,5785	0,6764	0,8552	1,0056
0,94	0,5658	0,6658	0,8498	1,0031
0,96	0,5532	0,6551	0,8444	1,0014
0,98	0,5407	0,6445	0,8389	1,0003
1,0	0,5283	0,6339	0,8333	1,0000
1,02	0,5160	0,6234	0,8278	1,0003
1,04	0,5039	0,6129	0,8222	1,0013
1,06	0,4919	0,6024	0,8165	1,0029
1,08	0,4800	0,5920	0,8108	1,0051
1,1	0,4684	0,5817	0,8052	1,0079
1,12	0,4568	0,5714	0,7994	1,0113
1,14	0,4455	0,5612	0,7937	1,0153
1,16	0,4343	0,5511	0,7879	1,0198
1,18	0,4232	0,5411	0,7822	1,0248
1,2	0,4124	0,5311	0,7764	1,0304
1,22	0,4017	0,5213	0,7706	1,0366
1,24	0,3912	0,5115	0,7648	1,0432
1,26	0,3809	0,5019	0,7590	1,0504
1,28	0,3708	0,4923	0,7532	1,0581
1,3	0,3609	0,4829	0,7474	1,0663
1,32	0,3512	0,4736	0,7416	1,0750
1,34	0,3417	0,4644	0,7358	1,0842
1,36	0,3323	0,4553	0,7300	1,0940
1,38	0,3232	0,4463	0,7242	1,1042
1,4	0,3142	0,4374	0,7184	1,1149
1,42	0,3055	0,4287	0,7126	1,1262
1,44	0,2969	0,4201	0,7069	1,1379
1,46	0,2886	0,4116	0,7011	1,1501
1,48	0,2804	0,4032	0,6954	1,1629
1,5	0,2724	0,3950	0,6897	1,1762
1,52	0,2646	0,3869	0,6840	1,1899
1,54	0,2570	0,3789	0,6783	1,2042
1,56	0,2496	0,3710	0,6726	1,2190
1,58	0,2423	0,3633	0,6670	1,2344
1,6	0,2353	0,3557	0,6614	1,2502
1,62	0,2284	0,3483	0,6558	1,2666

Ma	p/p_0	ρ/ρ_0	T/T_0	A/A^*	Ma	p/p_0	ρ/ρ_0	T/T_0	A/A^*
0.00	1.0000	1.0000	1.0000	∞	2.10	0.1094	0.2058	0.5313	1.8369
0.10	0.9930	0.9950	0.9980	5.8218	2.20	0.0935	0.1841	0.5081	2.0050
0.20	0.9725	0.9803	0.9921	2.9635	2.30	0.0800	0.1646	0.4859	2.1931
0.30	0.9395	0.9564	0.9823	2.0351	2.40	0.0684	0.1472	0.4647	2.4031
0.40	0.8956	0.9243	0.9690	1.5901	2.50	0.0585	0.1317	0.4444	2.6367
0.50	0.8430	0.8852	0.9524	1.3398	2.60	0.0501	0.1179	0.4252	2.8960
0.60	0.7840	0.8405	0.9328	1.1882	2.70	0.0430	0.1056	0.4068	3.1830
0.70	0.7209	0.7916	0.9107	1.0944	2.80	0.0368	0.0946	0.3894	3.5001
0.80	0.6560	0.7400	0.8865	1.0382	2.90	0.0317	0.0849	0.3729	3.8498
0.90	0.5913	0.6870	0.8606	1.0089	3.00	0.0272	0.0762	0.3571	4.2346
1.00	0.5283	0.6339	0.8333	1.0000	3.10	0.0234	0.0685	0.3422	4.6573
1.10	0.4684	0.5817	0.8052	1.0079	3.20	0.0202	0.0617	0.3281	5.1210
1.20	0.4124	0.5311	0.7764	1.0304	3.30	0.0175	0.0555	0.3147	5.6286
1.30	0.3609	0.4829	0.7474	1.0663	3.40	0.0151	0.0501	0.3019	6.1837
1.40	0.3142	0.4374	0.7184	1.1149	3.50	0.0131	0.0452	0.2899	6.7896
1.50	0.2724	0.3950	0.6897	1.1762	3.60	0.0114	0.0409	0.2784	7.4501
1.60	0.2353	0.3557	0.6614	1.2502	3.70	0.0099	0.0370	0.2675	8.1691
1.70	0.2026	0.3197	0.6337	1.3376	3.80	0.0086	0.0335	0.2572	8.9506
1.80	0.1740	0.2868	0.6068	1.4390	3.90	0.0075	0.0304	0.2474	9.7990
1.90	0.1492	0.2570	0.5807	1.5553	4.00	0.0066	0.0277	0.2381	10.7188
2.00	0.1278	0.2300	0.5556	1.6875					