LV. A Discourse on the Parallax of the Sun. By the Rev. Thomas Hornsby, M. A. Savilian Professor of Astronomy in the University of Oxford, and F. R. S.

THE quantity of the Sun's parallax is of such importance both to the theory and practical part of astronomy, that every method of determining it hath been employed by the astronomers of every age. Mr. Flamsteed informs us, in the 92d and 96th numbers of the Philosophical Transactions, that from some observations made upon the planet Mars, he had found the Sun's parallax not to exceed 10 seconds; and Dr. Halley, in a memoir written expressly with a view to ascertain the exact quantity of it, supposes it not to be greater than $12'' \frac{1}{2}$.

When we consider the imperfect state of astronomy at the time when Mr. Horrox lived, we cannot sufficiently admire the wonderful genius of that young gentleman, who at the age of 24 could collect from his own observations, that the parallax of the Sun did not exceed 14 seconds; while many celebrated astronomers, whose tables were then in the greatest repute, had assigned a parallax of more than two minutes to the Sun, which Kepler had supposed could not be less than 59 seconds, and which Hevelius, who published the admirable treatise of Mr. Horrox, intitled, Venus in Sole visa, fixed at 41 seconds.

In

In the year 1719, Dr. Pound and his nephew, that illuftrious aftronomer, Mr. Bradley, did, when Mars was in oppofition to the Sun, demonftrate (to ufe the words of Dr. Halley, Phil. Tranf. N°. 366, p. 114.) the extreme minutenefs of the Sun's parallax, and that it was not more than 12″, nor lefs than 9″, upon many repeated trials. At the fame time and by the fame kind of obfervations Mr. Maraldi determined this parallax to be 10′, the refult of his obfervations agreeing exactly with thofe deduced from the correfpondent obfervations by Mr. Richer at Cayenne and by Mr. Caffini at Paris in the year 1672.

The voyage which the Abbè de la Caille undertook, to perfect a catalogue of fome of the principal fixt ftars, furnifhed the aftronomers with the means of determining the Sun's parallax by correfponding altitudes of the planets Mars and Venus, to be obferved on each fide of the equator, with all the accuracy of which that method is capable The aftronomers here in Europe were invited to determine the diftances of the planets from particular ftars on ftated days, while the Abbè himfelf propofed to make the correfponding obfervations on the fouthernmoft part of Africa at the Cape of Good Hope. By the differences of the altitudes of the northern limb of Mars and of fuch ftars as were nearly in the fame parallel obferved on the fame day at the Cape with a fextant of 6 f. radius; at Greenwich by Dr. Bradley with a mural quadrant of 8 f.; at Bologna in Italy by M. Zanotti with a fimilar inftrument of 5f.; at the Royal Obfervatory at Paris by Meffieurs Caffini de Thury and Gentil with a moveable quadrant of 6 f.; and in Sweden by Meffieurs Wargentin, Stronmer and
Schem-

Schemmark, with telescopes of 7 and 8 f. armed with micrometers, it was found, when every reduction is made, that, according to each observation, the dates of which are given below, the horizontal parallax of the Sun, when at its mean distance from the earth, was as is represented in the following table.

Greenwich.		Bologna.		Paris.		Stockholm.		Upsal.		Hernosand.	
1751.	″	1751.	″	1751.	″	1751.	″	1751.	″	1751.	″
Aug. - - 30	9, 677	Aug. 31	9, 753	Sept. 13	9, 134	Sept. 1	10, 466	Sept. 2	9, 438	Sept. 25	9, 933
Sept. - - 13	9, 324	Sept. 1	9, 895	14	9, 715	25	10, 504	+ 24	12, 255	27	10, 618
14	9, 096	13	9, 971	+ 24	11, 912	Oct. + 3	12, 864	25	9, 715		
Oct. - - 3	10, 161	14	10, 238	Oct. 8	9, 895	5	10, 085	Oct. 6	9, 134		
4	10, 504	Oct. + 7	11, 075			6	9, 735				
7	9, 515										
+ 9	10, 961										
Mean of all	9, 891		10, 186		10, 164		10, 734		10, 135		10, 275
Mean rej.+	9, 712		9, 964		9, 581		10, 202		9, 421		

By taking a mean of all the observations, it follows that the Sun's mean horizontal parallax is 10″, 2; and if we reject the observations which differ most in excess from the rest, the mean will give 9,842 for the Sun's mean horizontal parallax.

Besides these 27 determinations, the Abbè de la Caille compared 41 observations, the mean of which is given in the following table.

N° of Obf.	Observations.	Instruments.	Places.	☉ Par.
				″
7	The late M. Caffini and M. Maraldi	Quadrant 2 f. rad.	Thury	8, 982
6	Mr. Delisle — at the Hotel de Clugny	Mur. circle 2 f.	Paris †	11. 532
3	Father Beraud	Refr. tel. 7 f.	Lyons	9, 020
6	M. M. Garipuy and d'Arquier	Ditto.	Touloufe	8, 944
12	M. Sabatelli and Father Carcani	Quad. 4 f. diag. div.	Naples	9, 933
7	M. Bofe	Tel. of 6 and 8 f.	Wittemberg	10 999
	Mean of all obferv. according to A. Caille			10, 210
	Mean of Refults (rejecting the 2d)			9, 575

Few obfervations of Venus near the inferior conjunction with the Sun on Oct. 31. 1751 were made, on account of the unfavourable weather here in Europe. By an obfervation made at Greenwich on Oct. 25, the mean horizontal parallax was 9″,8; but according to the obfervation made at Paris on the fame day at the Royal Obfervatory, that parallax was 11″,4. On Oct. 27, by an obfervation made at Paris, the ☉'s mean horizontal parallax was 9″,85; but by an obfervation at Bologna on the fame day it was found to be 10″,4——— By the obfervation at Paris on Nov. 17, the Sun's mean parallax was 10″,5. By a mean of all the obfervations of Venus, the Sun's mean parallax is 10″,38; and if we reject the Paris obfervation on Oct. 25, that parallax is 10″,13*.

We fee then that, according to thefe obfervations, the Sun's mean horizontal parallax is not lefs than 8″, 94. If we take a mean of the whole, that quantity is 10,09: But if we reject the obfervations that differ moft in excefs, the Sun's mean horizontal parallax will be found to be 9″,92 a determination in which every aftronomer might readily acquiefce, when he confiders the accuracy of the obfervers and the nice agreement of almoft all the obfervations.

And fuch was the ftate of the Sun's parallax as deduced from the lateft and beft obfervations, when the approaching tranfit of Venus in 1761 engaged the attention of the curious of all nations. Dr. Halley, in Philofophical Tranfactions, N°. 348, had propofed a method of determining the Sun's parallax

* See the Abbè de la Caille's Introduction to his Ephemerides Celeftes from 1765 to 1774.

by

by procuring obfervations to be made upon this tranf-
it in fuch places where the difference of time between
the ingrefs and egrefs would be the greateft poffible;
namely near the mouth of the Ganges, where the Sun
would be vertical at the middle of the tranfit, and
at Port-Nelfon in Hudfon's-Bay, where the planet
would enter upon the Sun's difk about the time of Sun-
fet, and leave it foon after Sun-rifing; for in the former
place, fays Dr. Halley, the planet would be equally
diftant from noon both at ingrefs and egrefs, and the
apparent motion of Venus upon the Sun would be ac-
celerated by almoft double the quantity of the horizon-
tal parallax of Venus from the Sun: becaufe Venus is
at that time retrograde, and moves in a direction con-
trary to that of the eye of an obferver upon the earth's
furface. Whereas in Hudfon's-Bay, under an oppofite
meridian, the eye of an obferver will be carried, while
the Sun feems to move under the pole from fetting to
rifing, in a direction contrary to the motion of the ob-
ferver's eye at the Ganges; that is, in the direction of
the planet's retrograde motion from eaft to weft.—From
thefe confiderations, and fuppofing with Dr. Halley the
axis of the planet's path to be inclined to the axis of the
equator in an angle of 2°.18′ only, the interval between
the two contacts would have been 15′. 10″ longer in
Hudfon's Bay than at the mouth of the Ganges.

But upon examination the cafe is found to be fome-
what different. The axis of the equator on the 6th
of June 1761 made an angle of 6° 10′ with the axis
of the ecliptic on one fide, and the axis of the planet's
path an angle of 8°.30′.10″ on the other; the
axis of the planet's path therefore made an angle with
the equator of 14°. 40′. 10″.— The planet's latitude
was 5¼ minutes greater both from obfervation and

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the Doctor's own tables, than he had fuppofed in his cal-
culation made from the Rodolphine tables corrected:
and therefore the planet's egrefs could not have been
obferved at Port Nelfon. Having made a computa-
tion for a place in North America fituated 5^h. $30'$ to
the weft of Greenwich, and in the 60th degree of
latitude; and alfo for a place to the eaft of Ganges,
and 6^h. $30'$ to the eaft of Greenwich in the latitude
of $22°$. $42'$ north, that the places might be nearly
fituated in the fame circumftances with the mouth of
the Ganges and Port Nelfon, I find that the interval
between the two contacts would be but $4'$. $56''$
longer in America than in the Eaft Indies, fuppofing
the Sun's parallax $12''.5$, and the inclination of
Venus's path $14°$. $40'$ to the equator.

And here perhaps it may not be altogether unnecef-
fary to enquire how far the miftake which Dr. Hal-
ley committed, by ufing the difference of the two an-
gles inftead of their fum, would influence the times
of the tranfit as feen at Ganges and Port Nelfon.
For this purpofe I made ufe of the fame elements
which Dr. Halley has given in his paper, and calcu-
lated the angle of the vertical with the orbit of Venus
at the two internal contacts at both places, fuppofing
the orbit to be inclined firft only $2°$. $18'$ to the equa-
tor, agreably to Dr. Halley's fuppofition, and alfo
$14°$. $40'$. and I found that the duration would be
$15'$. $13''$ longer at Hudfon's-Bay than at the Ganges
upon the firft fuppofition; and $14'$. $44''$, if the circles
be duly inclined to each other; the difference being
only 29 feconds. It has already been found by cal-
culation, fuppofing the latitude of Venus to be about
$9\frac{1}{2}$ minutes, that the difference of duration at the
two places would have been only $4'$. $56''$. It may
fairly

fairly therefore be concluded that the tranfpofition of the circles contributed very little towards giving fo different a refult, the reafon of which need not here be mentioned; and Dr. Halley feems to have been led into the miftake entirely from fuppofing the latitude of Venus to be about 4'. 0" according to the tables, which he then ufed, conftructed upon the principle that the nodes of that planet were fixed.— Having determined that the difference of duration at the two places above mentioned would be 15'. 10" (differing only 3" from the method I ufed which is independent of projection) the Doctor proceeds to fhew, that if Venus had no latitude at the time of the middle of the tranfit, the difference would be 18'.40"; and if the planet fhould pafs 4'.0" to the north of the Sun's center, that difference would be 21'. 40", and would become ftill greater, if the planet's north latitude fhould be farther increafed. And fuch would have been the event, had the motion of the nodes been progreffive. But, agreably to the principles of univerfal attraction, their motion is really retrograde, and this Dr. Halley fays he himfelf fufpected, *ut ob nuperas quafdam obfervationes fufpicio eft*. And therefore it is fomewhat furprifing that he did not determine by calculation what would have been the difference in the whole duration between the two places, if Venus fhould pafs more to the fouthward of the Sun's center, then he had fuppofed. He would then immediately have perceived that the two ftations were not fo advantageoufly placed, as the folution of the problem required.

Obfervers were therefore to be fent to other places, in order to determine the Sun's parallax agreeably to the method propofed by Dr. Halley. The city of
Tobolfki

Tobolſki in Siberia is ſo ſituated, that the interval be-
tween the two contacts was perhaps as ſhort as could
poſſibly be obſerved on any part of the earth's ſur-
face; to this place was ſent the Abbè Chappe d'Au-
teroches, one of the French aſtronomers. Near Hud-
ſon's Bay and in 60° of latitude the duration would
have been 5 minutes longer, ſuppoſing the Sun's par-
allax $= 9''$. At Bencoolen, where it was firſt propoſed
to ſend Meſs. Maſon and Dixon, the difference
would have been about $4\frac{1}{2}$ minutes. At the iſland
of Rodrigues, where Mr. Pingré could only obſerve
the laſt internal contact, the difference would have
been about $7\frac{1}{2}$ minutes. On the ſouthern coaſt of
New-Holland, it would have been ſomewhat more
than 10 minutes. And in the great Indian Ocean,
under $115\frac{1}{4}$ of abſolute longitude from the Iſle of
Ferro and in 57° of ſouth latitude, where the begin-
ing of the tranſit would happen ſoon after Sun-riſ-
ing, and the end juſt before Sun-ſet, the difference
would amount to $13\frac{1}{4}$ minutes. The greateſt differ-
ence between the interval of the two internal contacts,
as determined by actual obſervation on the 6th of
June, was $2'.49'', 75$, a quantity hardly ſufficient to
determine the Sun's parallax agreeably to the method
propoſed by Dr. Halley.

I have however made the neceſſary calculations,
and compared the duration of the tranſit obſerved at
ſeveral places with the duration as obſerved at To-
bolſki. The parallax reſulting from each obſervation
is contained in the following table, in which the 3d
column contains the obſerved duration, the 4th the
difference of each obſerved duration; the next con-
tains that difference as deduced by computation upon
a ſuppoſition that the Sun's parallax is $9''$. In the
laſt

laſt column is given the horizontal parallax on the day of the tranſit, reſulting from a compariſon of the 4th and 5th columns.

Places.	Obſervers.	Obſerved duration.	Difference of obſerv'd dur.	Difference by calculation.	Sun's Parallax.
		h ′ ″	″	′ ″	″
Tobolſki	Abbe Chappe	5 48 53,25			
Cajaneburg	Mr.Planmann	5 49 54	1 00, 75	1 00, 88	8, 980
Tornea°	Hellant	5 50 09	1 15, 75	1 05, 27	10, 444
Tornea°	Lagerborn	5 50 21	1 27, 75	1 05, 27	†12, 098
Upſal	Bergman	5 50 26	1 32, 75	1 33, 78	8, 901
Upſal	Mallet	5 50 07	1 13, 75	1 33, 78	† 7, 077
Upſal	Strömer	5 50 02	1 08, 75	1 33, 78	† 6, 597
Hernoſand	Gifter	5 50 26	1 32, 75	1 25, 76	9, 733
Abo	Juſtander	5 50 09	1 15, 75	1 20, 68	8, 450
Stockholm	Wargentin	5 50 45	1 51, 75	1 34, 21	10, 675
Stockholm	Klingenſtiern	5 50 42	1 48, 75	1 34, 21	10, 389
Calcutta	Magee	5 50 31	1 37, 75	1 37, 02	9, 067
Madraſs	Hirſt	5 51 43	2 49, 75	2 39, 50	9, 577

Mean of the whole – – – – – – – – – – –	9, 332
Mean, rejecting 2 obſervations at Upſal and 1 at Tornea-	9, 579

The duration at Cajaneburg was the ſhorteſt except at Tobolſki; with which if we compare the duration obſerved at Madraſs the parallax is 9″,948: and by taking a mean of the parallax deduced from a compariſon of the obſervation at Madraſs with thoſe of Tobolſki and Cajaneburg, the parallax is 9″,762.

The obſervations at the above places agree as well together as can be expected from ſuch ſmall differences in the duration, which muſt in ſome meaſure be influenced by the neceſſary and unavoidable errors in obſervation.

If

If the quantity of the fun's diameter, and the leaft diftance of the centers were very exactly known, tha Sun's parallax might fafely be determined by comparing the duration of the tranfit as obferved at different places with the duration as fuppofed to be feen from the ear h's center. According to this method, fuppofing the leaft diftance of the centers to be $9'.29''\frac{1}{4}$, which is a mean between the Greenwich Shirburn and Paris obfervations, and the difference of the femidiameters of the Sun and Venus$=916''$,4, the duration as of ferved at Tobolfki was more than 10 minutes fhorte than if feen without parallax; at Tornea°, at Stock iolm, at Cajaneburg, at Aftracan, and indeed in almoft every part of Europe and Afia, the duration was confiderably fhortened; and if a number of good obfervations made in feveral of thofe parts were procured, the Quantity of the Sun's, parallax might be well enough afcertained, as the difference in duration for a difference of one fecond in the Sun's parallax will be found very confiderable.

Tho' this method fhould not be practifed, unlefs the neceffary requifites for the computation be known with fome degree of precifion, I have ventured to compare the durations obferved chiefly in the northern parts of Europe, and fome in Afia, with the duration, as feen from the earth's center,$=5^h.59'.19'',10$ mean time, or $5^h.59'.16'',64$ apparent time, and calculated from the elements above mentioned.

Places

Places.	Obferved durations.	Duration without parallax.	Difference of durations.	Differ. for 1″ of parallax.	Sun's parallax.
	h ′ ″	h ′ ″	′ ″	″	″
Tobolfki - - -	5 48 53 25	5 59 16, 64	10 23, 39	64, 09	9, 726
Cajaneburg -	5 49 54		9 22, 64	57, 32	9, 815
Tornea° - -	5 50 09		9 17, 64	56, 83	9, 636
Tornea° - -	5 50 21		8 55, 64	56, 83	9, 425
Abo - - -	5 50 09		9 07, 64	55, 12	9, 935
Upfal - -	5 50 26		8 50, 64	53, 67	9, 888
Upfal -- -	5 50 07		9 09, 64	53, 67	10, 241
Upfal - -	5 50 02		9 15, 64	53, 67	10, 352
Hernofand -	5 50 26		8 50, 64	53, 65	9, 890
Stockholm -	5 50 42		8 34, 64	53, 62	9, 579
Stockholm -	5 50 45		8 31, 64	53, 62	9, 523
Calcutta - -	5 50 36		8 40, 64	53, 31	9, 766
Madrafs - -	5 51 43		7 33, 64	46, 36	9, 785

N. B. The 4th column contains the difference between the obferved and calculated duration; in the 5th is given the difference in the duration for a difference of 1″ in the ☉'s parallax, and the 6th column is obtained by dividing the 4th by the 5th.

The mean of all the refults is 9″,812: and if we rejeƈt two of the obfervations at Upfal, which differ moft in excefs, the Sun's parallax is 9″,724, agreeing very nearly with the quantity refulting from a comparifon of fome of the obferved durations with the fhorteft obferved at Tobolfki and Cajaneburg.

We may alfo proceed to find the Sun's parallax by means of the leaft diftance of the centers as obferved in two or more places where the effeƈt of parallax was contrary; or if the leaft diftance of the centers was only determined at one place, it may be found by calculation at any other place, where the total duration was obferved. But in this and the laft cafe the elements of calculation are required with fo rigorous

exactnefs, that perhaps thefe methods are only to be
called in to illuftrate and confirm the others.

Mr. Pingré confined himfelf principally to the de-
termination of the leaft diftance of the centers. At
$21^h.43'.11''$ he found the diftance between the neareft
limbs of Venus and the Sun to be the greateft
$= 5'.57'',2.$ or $5'.57'',4$ when corrected by refrac-
tion. This diftance being fubtracted from $15'.19'',5$
the difference of the Semidiameters, leaves $9'.22'',1$
for the leaft apparent diftance of the centers. But as
that obfervation was made rather too late, when the
diftance of the centers was greater than it ought to
be, he found by calculation that it fhould be dimi-
nifhed by $0'',22.$ The true apparent leaft diftance
of the centers by actual obfervation was therefore
$9'.21'',88.$ In order to be more fecure of this re-
fult, Mr. Pingré compared a large number of ob-
ferved diftances, both at the beginning and towards
the middle of the tranfit, with the diftance deter-
mined by internal contact, and after excluding every
doubtful obfervation, he found the leaft apparent
diftance of the centers to be $9'.21'',69.$ By com-
paring this diftance with the diftance deduced from
the total duration as obferved at any place (the me-
thod of finding which he has given at large in his
memoir inferted in the Memoirs of the academy
of fciences for 1761) and by knowing from cal-
culation what influence a parallax of $10''$ for inftance
would have upon thofe diftances, he found the Sun's
parallax as in the following table.

Places

Places.	Obferved durations.	L. diftance of centers from the durations.	L. diftance deduced from calculation.	Sun's parallax.
	h ′ ″	′ ″	′ ″	″
Tobolſki - - - - -	5 48 53, 25	9 51, 53	9 52, 24	10, 125
Stockholm - - -	5 50 43, 5	9 54, 85	9 55, 83	10, 03
Upſal - - - - - -	5 50 26	9 55, 62	9 55, 95	10, 23
Cajaneburg - - - -	5 49 54	9 55, 61	9 55, 61	10, 00
Tornea° - - - - -	5 50 09	9 55, 28	9 56, 08	10, 09

By taking a mean of thefe determinations, we find the Sun's parallax to be 10″,1. In the above calculations the Sun's femi-diameter was fuppofed = 15′.48″,5, and that of Venus 29″. Obfervers, fays Mr. Pingré, have found the former to be about 2″ lefs, and the latter on the contrary half a fecond larger. By calculating upon the fuppofition of a difference of 2″ in the difference of the femidiameters of the Sun and Venus, the leaft diftance of the centers at Tobolſki, Stockholm, Upfal, Tornea°, and Cajaneburg, ought to be 3″, 12 lefs, and at Rodrigues 2″,56 or 2″,60, and the Sun's horizontal parallax ought alfo to be 0″,17 lefs. If then this correction be admitted, which is warranted by the beft obfervations, the Sun's horizontal parallax will be 9″,92.

There is ftill another method by which we are enabled to determine the Sun's parallax, by comparing the obfervations made in different places where the effect of parallax upon the planet is confiderable at the times of the two contacts. It was more convenient to make ufe of the 2d internal contact for this purpofe, and the obfervers were very advantageoufly ftationed at St. Helena and the Cape of Good

Hope:

Hope: for by comparing the obfervations made there with thofe at Tornea°, Tobolſki, and in fome of the Eaſtern parts of Afia, the difference of the times of the contacts when reduced to the fame meridian will be found to be very confiderable, amounting to more than $9\frac{1}{2}$ minutes at the two firſt places above mentioned, and being greater, as the places are farther fituated to the North-Eaſt. But if this method be ufed, it is abfolutely neceffary that the longitudes of the places fhould be determined with the utmoſt accuracy, fince an error of a few feconds would have a confiderable influence upon the refult, and would increafe or diminifh the quantity of the Sun's parallax, in proportion. The unfavourable ſtate of the heavens at the time of the internal contact prevented the Rev. Mr. Maſkelyne from making an obfervation at the Ifle of St. Helena; which is the more to be lamented as his obfervation would have confirmed or corrected the obfervation at the Cape, if neceffary; fince the effect of parallax at both places would have been very nearly the fame. The obfervers at the Cape were more fortunate, and differed only 4″ in their obfervation of the internal contact. — But before we proceed to deduce the quantity of the Sun's parallax, by comparing as well the obfervation made at Greenwich as thofe at other places, with the obfervation at the Cape, it will be neceffary to lay before the reader the authorities upon which the longitude of each place has been determined.

The longitude of the Cape of Good-Hope was not even nearly known till the Abbé de la Caille went thither in the year 1751. By a comparifon of 9 eclipfes of Jupiter's fatellites as well immerfions as emerfions obferved at the Cape with the correfpond-

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ley's tables has followed that determination, which has alfo been generally ufed by the Englifh Aftronomers. — The French Aftronomers have till very lately imagined the difference of meridians to be 9′.10″. as deduced from a fingle obfervation of an eclipfe of Jupiter's firft fatellite made by Mr. Caffini when in London, with a telefcope of fimilar fize and conftruction with that ufed at Paris when the fame eclipfe was obferved. — In the year 1734 Mr. Maraldi publifhed a comparifon of 33 eclipfes obferved at Greenwich by Mr. Flamfteed, and at Paris by the French Aftronomers, 19 of which are immerfions, and the reft emerfions. The longitudes refulting from each correfpondent obfervation differ widely from each other, the two obfervatories being 11′.27″ diftant by an immerfion of the 2d fatellite, and only 7′ 43″ by an emerfion of the firft. But if we take a mean of the whole, the difference of longitude will be 9′.24″; and if we exclude the obfervation of the 2d fatellite above mentioned, which muft be very faulty, the difference of meridians will be 9′.22″, a refult which in all probability is but a very few feconds from the truth. It may be obferved that the immerfions all give the difference of longitude too great, and almoft all the emerfions too little; a circumftance owing either to the badnefs of the air here in England, or to an inequality in the goodnefs of the telefcopes, or perhaps to both; for whatever was the advantage in obferving the immerfions, was ballanced by the emerfions: for which reafon whenever the eclipfes of Jupiter's fatellites are ufed, the longitude fhould, if poffible, be deduced both from immerfions and emerfions.

As the obfervations of tranfits of Mercury may be very ufeful in fettling the longitudes of places which

are

are not far diſtant, I have examined the ſeveral obſer-
vations that I can meet with made at Paris, and either
immediately at Greenwich or in ſuch parts of London
whoſe longitude from Greenwich is known within one
ſecond of time. And the reſult of ſuch compariſons
is as follows.

On the 29th of October 1723 Dr. Halley obſerved
the firſt interior contact of the limbs of Mercury and
the Sun at $2^h.42'.26''$ apparent time at Greenwich.
The Rev. Mr. Profeſſor Bradley obſerved the ſame
at $2^h.42'.38''$, at Wanſted in Eſſex ($10''$ to the Eaſt of
Greenwich) or at $2^h.42'.28''$ when reduced to the
meridian of Greenwich. Mr. Graham in Fleetſtreet
obſerved the ſame at $2^h.42'.19''$, or at $2^h.42'.44''$,
when reduced to Greenwich. The mean of theſe
is $2^h.42'.32'',7$. In the obſervatory at Paris Mr.
Maraldi obſerved the ſame at $2^h.51'.48''$ apparent
time; and Mr. Deliſle at $2^h.51'.37'$, but ſuſpects it
might have been ſome few ſeconds later. I will
ſuppoſe it to have happened at $2^h.51'.43''$, 5.
The difference of meridians therefore is $9'.10'',8$.
If we take a mean of Dr. Halley's and Mr. Bradley's
obſervations only, the difference of meridians is
$9'.16'',5$.

In the year 1736 Dr. Bevis obſerved the laſt con-
tacts of the limbs of Mercury and the Sun at
$0^h 8'.33''$ at Greenwich. The ſame was obſerved
at Paris by M. Maraldi and M. Caſſini de Thury, and
at Thury by Mr. Caſſini, at $0^h.18'05'',5$ by a mean
of the three obſervations. The difference of longi-
tude therefore is $9'.32'',5$.

In the year 1743 the laſt internal contact of the
limbs was obſerved by Mr. Graham in Fleetſtreet at
$1^h.0'.42''$, and by Dr. Bevis at Beaufort-Buildings in
the

the Strand at $1^h.0'.33''$: or by a mean of both when reduced to the meridian of Greenwich at $1^h.1'.04''$.—— The fame was obferved by the Abbé de la Caille, by Meff. Maraldi, Monnier, and Caffini the fon, at Paris, and by Mr. Caffini at Thury : which obfervations, when reduced to the meridian of the Royal Obfervatory, give $1^h.10''.15'',5$ for the time of the internal contact: the difference of meridians is therefore $9'.12''.5$. —— By a mean of the obfervations of Mr. Graham and Dr. Bevis when reduced to Greenwich, the laft external contact on the fame day happened at $1^h.2'.42''$. and by a mean of the obfervations in France the fame happened there at $1^h.12'.10''$. The difference of longitude therefore is $9'.28''$. N B. No obfervations were made of this tranfit at the Royal Obfervatory at Greenwich, on account of clouds.

In the year 1753 was another tranfit of Mercury, when the unfavourable ftate of the heavens a few feconds before the time of the internal contact prevented any obfervations from being made at Greenwich, as appears from a paper communicated to me by the executors of the late Dr. Bradley. Both contacts however were luckily very well obferved, by Mr. Short, Dr. Bevis and Mr. Bird; by a mean of whofe obfervations reduced to the meridian of Greenwich the internal contact happened at $10^h.9'.37'',5$. The fame contact was obferved by 13 obfervers at Paris, and was found not to happen fooner than $10^h.18'.36''$, nor later than $10^h.19'.03''$. But by a mean of all at $10^h.18'.45''$. The difference of meridians therefore is $9'.07'',5$. By a mean of the obfervations of Mr. Short, Dr. Bevis, Mr. Bird, Mr. Canton, and Mr. Siffon, all reduced to the meridian of Greenwich, the external
contact

contact happened at $10^h.12'.17'',5$. and at the Royal Obfervatory, by a mean of all the obfervations at Paris, at $10^h.21'.33''$. The difference of longitude therefore is $9'.15'',5$. And if we take a mean of thefe 7 refults, the Royal Obfervatory at Paris will be found to be $9'.17'' \frac{1}{2}$ to the Eaft of the Royal Obfervatory at Greenwich, a determination very nearly agreeing with that mentioned by Sir Ifaac Newton, and which, I believe, was deduced from a comparifon of Dr. Halley's and Mr. Caffini's obfervations.

The Abbé de la Caille, in his memoire on the parallax of the Moon, fuppofes the difference of meridians to be $9'.17''$ tho' he has not mentioned from what authority he drew that conclufion. I fhall therefore fuppofe the difference of meridians to be $9'.17'$.—The laft internal contact was obferved at Paris by Mr. de la Lande at $20^h.28' 25''$ or $26''$; at $20^h.28'.26''$ by Father Clouet, and by Mr. Maraldi and Mr. Barros feparately at $20^h.28'.42'$. Mr. Pingré, in a very curious memoire on the Sun's parallax already referred to, fuppofes the internal contact to have happened at Paris at $20^h.28'.38''$. I fhall therefore make ufe of the Abbé de la Caille's obfervation at $20^h. 28'. 37'' \frac{1}{2}$.

The difference of meridians between Paris and Stockholm, fays Mr. Wargentin, is $1^h.2'.51''$ or $52''$ at moft. Mr. de la Lande from a comparifon of 17 obfervations of the firft fatellite of Jupiter made from 1750 to 1759 and communicated to him by Mr. Wargentin, determines the difference of longitude to be $1^h.3'.10''$. And the Abbé de la Caille, in his memoire on the Moon's parallax, fuppofes it to be $1^h.3'.13''$. As thefe two laft determinations agree fo nearly together, I fhall fuppofe Stockholm to be

$1^h.3'$

$1^h.3'.10''$ to the Eaſt of Paris, and $1^h.12'.27''$ to the Eaſt of Greenwich; and the laſt internal contact to have happened at $21^h.30'.09'',5$, which is a mean between the obſervations of Meſſ. Wargentin and Klingenſtiern.

The City of Cajaneburg in Sweden is $38'.40''$ to the Eaſt of Stockholm, according to very late obſervations; and therefore Cajaneburg is $1^h.51'.07''$ to the Eaſt of Greenwich. The 2d internal contact happened at $22^h.7'.59''$, when the error in writing down the minutes is corrected according to the inſtruction given in Philoſophical Tranſactions, for 1761, p. 231. Indeed (ſuppoſing the longitude of Cajaneburg as above ſet down to be exact) it is very eaſy to prove that the error of one minute was made at the egreſs rather than at the ingreſs.

The City of Tobolſki in Siberia (according to the obſervation of the end of the ſolar eclipſe on June 3d by Mr. Chappe and Mr. Planmann at Cajaneburg and calculated by Mr. Pingré) is $2^h.42'.11''$ to the Eaſt of Cajaneburg; and this determination is alſo confirmed by Mr. Wargentin's obſervation of the ſame phaſe. Tobolſki therefore is $4^h.33'.18''$ to the Eaſt of Greenwich: and I ſuppoſe Mr. Chappe to have obſerved the laſt internal contact at $0^h.49'.23'' \frac{1}{2}$, without making any allowance for the luminous ring which appeared round Venus in his teleſcope.

The Obſervatory at Upſal (according to Mr. Wargentin in the Philoſophical Tranſactions) is $1^h.1'.10''$ to the Eaſt of Paris, and is therefore $1^h.10'.27''$ to the Eaſt of Greenwich. By taking a mean of the three obſervations made there, the internal contact happened at $21^h.28'.06''$.

Tornea°

Tornea⁰ has been generally fuppofed to be
$1^h.27'30''$ to the Eaft of Paris; but with this differ-
ence of meridians, the obfervations at Tornea°, tho'
made by Mr. Hellant, a very excellent obferver, will
give a parallax of the Sun much lefs than the other
obfervations made in high Northern latitudes. In
order to fettle the longitude of this place, I am of
opinion that we may have recourfe with fafety, and
without incurring the charge of reafoning in a circle,
to the obfervation of the tranfit itfelf; I mean the
obfervation of the internal contact at the ingrefs.
Whether we fuppofe the Sun's parallax to be $8''$ or
$10''$, the firft internal contact would have happened
fooner at Tornea° than at Stockholm $19''$ or $24''$. As
the Sun's parallax will readilly be allowed to be more
than $8''$, I fhall fuppofe the firft internal contact to
have happened $21''$ fooner. Tornea⁰ is therefore
$24'55''$ to the Eaft of Stockholm, and confequently
$1^h.37'.22''$ to the Eaft of Greenwich. I fhall make
ufe of Mr. Hellant's obfervation of the internal con-
tact at $21^h.54'.08''$ in preference to that of Mr. La-
gerbom.

Abo, the capital of Finland, where Mr. Juftander
obferved the laft internal contact at $21^h.45'.19''$ (when
a correction is made in the minutes) is $1^h.11'.29''$ to
the Eaft of Paris, and $1^h.28'.34''$ to the Eaft of
Greenwich.

At Hernofand, which is $1^h.11'.29''$ to the Eaft of
Greenwich, I fhall fuppofe the 2d internal contact
was obferved at $21^h.28'.52''$, as publifhed in the Phi-
lofophical Tranfactions by Mr. Short from the Swed-
ifh acts.

I find the Ifland of Rodrigues by comparing three
obfervations of eclipfes of Jupiter's fatellites with

others

others made in England and at the Cape, to be
$4^h.12'.38''$ to the East of Greenwich: and this deter-
mination is exactly confirmed by Mr. Pringré's com-
parifon of the fame eclipfes. The obfervation of the
occultation of a fixt ftar gives the longitude $6''$ or $7''$
greater. In the Philofophical Tranfactions, and even
in the former part of the volume of the Memoirs of
the Academy of Sciences for 1761, we find the inter-
nal contact was obferved at Rodrigues at $0^h.34'.47''$;
And yet in the memoire on the Sun's parallax it is faid
to have happened at $0^h.36'.49''$. Upon comparing
this latter with the time by the clock, it fhould feem
that Mr. Pingré had committed a miftake in fubtract-
ing the error of his clock inftead of adding it. But he
has no where mentioned any reafon for this difference.

Gottingen, where the celebrated Mr. Mayer ob-
ferved the firft internal contact at $20^h.58'.26''$
to the Eaft of Paris is $30'$ $16''$ or $39'$ $33''$ to the Eaft
of Greenwich.

The Abbé de la Caille has placed Bologna $36'.03''$
to the Eaft of Paris: By comparing the obfervations
of the tranfit of Mercury, I find, by a mean of three
refults agreeing very nearly together, that Bologna is
$45'.15''$ to the Eaft of Greenwich. Mr. Zanotti ob-
ferved there the 2d internal contact at $21^h.04'.34''$.
But as he ufed a refracting telefcope of $2\frac{1}{2}$ feet, and
as two other obfervers with telefcopes of 10 and 22
feet faw the contact $24''$ later, I fhall fuppofe it to have
happened at 21^h $4'$ $58''$.

At Florence, the internal contact was obferved
with a reflector of more than 4 feet at $21^h.4'.28''$ by
Father Ximenes. The longitude of this place is
$34'$ $48''$ to the Eaft of Paris, according to the table in
the Connoiffance des Mouvemens Celeftes, or $35'.58''$
according

according to the table in the Elemens d'Aſtronomie by Mr. Caſſini. By taking a mean of both, Florence is 44′.40″ to the Eaſt of Greenwich.

The longitude of St. Peters at Rome is 49′.54″ according to the French Aſtronomers. The internal contact was obſerved to happen at 21ʰ.09′.36″. But as it is not ſaid where this obſervation was made, the longitude given above will be found to be ſomewhat inaccurate.

Obſervations were alſo made at Madrid and Liſbon; at the former, the internal contact happened at 20ʰ.6′.56″ apparent time : and at Liſbon at 19ʰ.44′.26″. The longitude of Madrid, as given in the Philoſophical Tranſactions, is certainly erroneous; being more than a minute and a half too little, if the obſervation of the tranſit can be depended upon. At Liſbon, the longitude of the place was not determined by Mr. Ciera, who obſerved the tranſit, when Mr. Pingré, from whom I have taken the obſervation, left it in his way from Rodrigues. From the beſt accounts that I can collect, particularly from the 385th number of the Philoſophical Tranſactions, and from an account of ſome obſervations by Mr. Short, Liſbon is about 36′.26″ to the Weſt of Greenwich.

Now in order to deduce the Sun's parallax from the obſervations related above, I proceeded in the following manner. Having ſubtracted the difference of longitude between Greenwich and the Cape =1ʰ.13′.28″ from 21ʰ.39′.52″ the mean of the obſerved times at the Cape, and compared the remainder with the obſerved time at Greenwich, I find that the internal contact was obſerved 7′.24″ later at the Cape

I   than

than at Greenwich, on account of parallax. I then calculated what would be the effect of parallax at each place, suppofing the Sun's parallax to be 9 feconds; and found that the time of the internal contact would be accelerated $1'.16'',63$ at Greenwich, and retarded $6'.31',09$ at the Cape: the whole effect of parallax therefore is $7'.47'',72$. But the difference in time, as found by obfervation, is only $7'.24''$: and therefore the difference by calculation is to the difference by obfervation, as the affumed parallax is to the true parallax on the day of the tranfit, which by this obfervation is $8'',543$. The parallax refulting from each obfervation will be found in the following table, which will be fufficiently explained by the foregoing example.

Places.	Difference of calculated times.		Difference of obferved tim:		Sun's parallax.
	'	''	'	''	''
Greenwich - - - - - - -	7	47, 72	7	24	8, 543
Paris - - - - - - - -	7	28, 40	7	03, 5	8, 494
Stockholm - - - - - -	8	53, 72	8	41, 5	8, 712
Upfal - - - - - - - -	9	01, 83	8	45	8, 727
Cajaneburg - - - - - -	9	42, 30	9	32	8, 841
Tobolfki - - - - - - -	10	29, 06	10	18, 5	8, 848
Tornea° - - - - - - -	9	48, 95	9	38	8, 832
Abo - - - - - - - - -	9	11, 16	8	59	8, 801
Hernofand - - - - - -	9	21, 17	9	01	8, 676
Rodrigues - - - - - -	3	19, 72	2	13	5, 993
Gottingen - - - - - -	7	54, 36	7	31	8, 558
Bologna - - - - - - -	7	03, 31	6	41	8, 525
Florence - - - - - - -	6	57, 79	6	36	8, 536
Rome - - - - - - - -	6	45, 16	6	41	8, 907

Such

Such is the refult of a comparifon of the beft ob-
fervations made in places whofe longitudes are as ac-
curately afcertained as the prefent ftate of Aftronomy
will permit: by a mean of the whole, rejecting only
the obfervation at Rodrigues, the Sun's parallax on
the day of the tranfit is 8′,692. — I have excluded
the comparifon of the obfervation at Rodrigues, be-
caufe the parallax refulting from it differs fo confider-
ably from the reft. If we fuppofe the internal con-
tact to have really happened one minute fooner,
through a miftake in writing down the obfervation,
the parallax will then be 8′,697.

This obfervation made at Rodrigues, fuppofing it
exact, will furnifh another term wherewith to com-
pare the feveral obfervations made in Europe. The
Sun's parallax refulting from each obfervation may be
feen in the following table.

Places.	Difference of calculated times.	Difference of obferv'd times.	Sun's parallax.	Difference of obferved times.	Sun's parallax.
	′ ″	′ ″	″	′ ″	″
Greenwich - - - -	4 28,00	5 11	10,444	4 11	8,429
Paris - - - -	4 8,98	4 50,5	10,500	3 50,5	8,332
Stockholm - -	5 39,00	6 28,5	10,314	5 28,5	8,721
Upfal - - - -	5 42,11	6 32	10,312	5 32	8,734
Cajaneburg - -	6 22,58	7 19	10,327	6 19	8,915
Tobolfki - - - -	7 09,34	8 05,5	10,177	7 05,5	8,919
Tornea° - - - -	6 29,23	7 25	10,289	6 25	8,902
Abo - - - -	5 51,46	6 47	10,422	5 47	8,886
Hernofand - -	6 01,45	6 49	10,183	5 49	8,690
Gottingen - -	4 34,64	5 18	10,421	4 18	8,454
Bologna - - -	3 43,59	4 33	10,787	3 33	8,372
Florence - - -	3 38,07	4 23	10,854	3 23	8,449
Cape of Good Hope -	3 19,72	2 13	5,993	3 13	8,697

The

The mean of the whole, rejecting the comparison of the Cape, is 10″,419; suppofing the internal contact to have happened at 0ʰ.36′.49″. But if a miftake of one minute was really committed, the 3d column will receive a confiderable alteration and the parallax refulting from each obfervation will be reprefented in the laft column, the mean of which is 8″,654, agreeing as nearly as poffible with the parallax refulting from all the beft obfervations compared with the Cape.

Mr. Pingre finding the parallax refulting from his own obfervation to differ fo widely from that deduced from the Cape, and that both obfervations might be made to agree by fuppofing an error of one minute in the obfervation at Rodrigues, has examined every fource of error that might be committed; and upon the whole fees reafon to prefer his own obfervation to that of Mr. Mafon, *not becaufe he could find no miftake in his own, but becaufe he has proved that no miftake could poffibly be committed.* His obfervation indeed is in fome meafure confirmed by comparing all the obfervations with that at Lifbon: from which comparifon if the longitude above laid down may be depended upon, the Sun's parallax is fomewhat more than 10 feconds.

The feveral obfervations, that have been compared with the obfervations both of the Cape and Rodrigues, may alfo be compared together; and by combining fome of them, we may obtain different refults, upon which we may more or lefs depend, as the differences between the obferved times are greater or lefs.

Places

Places compared.	Difference of calculated times.		Difference of obferv'd times.		Sun's parallax.
	′	″	′	″	″
Tobolſki and Greenwich - - -	2	41, 34	2	54, 5	9, 734
Tobolſki and Paris - - - - -	3	0, 36	3	15	9, 736
Tobolſki and Gottingen - - -	2	34, 70	2	47, 5	9, 744
Tobolſki and Stockholm - - -	1	30, 34	1	37, 0	9, 663
Tobolſki and Upſal - - - -	1	27, 23	1	33, 5	9, 646
Tobolſki and Bologna - - - -	3	25, 75	3	37, 5	9, 513
Tobolſki and Florence - - - -	3	31, 27	3	42, 5	9, 525
Stockholm and Greenwich - -	1	11, 0	1	17, 5	9, 824
Stockholm and Paris - - - -	1	30, 02	1	38, 0	9, 797
Stockholm and Bologna - - -	1	55, 41	2	00, 5	9, 396
Stockholm and Florence - - -	2	0, 93	2	05, 5	9, 340
Tornea° and Gottingen - - -	1	54, 59	2	07	9, 974
Tornea° and Paris - - - - -	2	20, 25	2	34, 5	9, 914
Tornea° and Greenwich - - -	2	1, 23	2	14	9, 948
Cajaneburg and Greenwich - -	1	54, 58	2	08	10, 054
Cajaneburg and Paris - - -	2	13, 60	2	28, 5	10, 003
Cajaneburg and Gottingen - -	1	47, 94	2	01	10, 088
Cajaneburg and Florence - -	2	44, 51	2	56	9, 628
Cajaneburg and Bologna - -	2	38, 99	2	51	9, 679
Upſal and Paris - - - - -	1	33, 13	1	41, 5	9, 808
Upſal and Greenwich - - - -	1	14, 11	1	21	9, 836
Hernoſand and Paris - - - -	1	52, 47	1	57, 5	9, 402
Hernoſand and Greenwich - -	1	33, 45	1	37	9, 342
Hernoſand and Bologna - - -	2	17, 86	2	20	9, 139
Hernoſand and Florence - - -	2	23, 38	2	25	9, 101
Abo and Paris - - - - - -	1	42, 46	1	55, 5	10, 145
Abo and Greenwich - - - -	1	23, 44	1	33	10, 031
Abo and Bologna - - - - -	2	07, 85	2	18	9, 714
Abo and Florence - - - - -	2	13, 37	2	23	9, 649
Tornea° and Bologna - - - -	2	45, 64	2	57	9, 617
Tornea° and Florence - - - -	2	51, 16	3	02	9, 569
Greenwich and Paris - - - -	0	19, 02	0	20, 5	9, 700

The mean of the whole is 9″, 695.

It has been shewn that the parallax result-
ing from the total durations ——— is } 9, 579

— from a comparison of the observation at
Madrafs with those of Tobolski and Ca-
janeburg is — ——— } 9, 763

— from a comparison of the observed, with
a calculated, duration without parallax, is } 9, 724

— from the least distance of the centers — 9, 920

— from the observations combined together is 9, 695

It can hardly be supposed that as such different me-
thods give a parallax of the Sun on the day of the
transit equal to 9″,736, that this parallax should yet
be only 8,692 as deduced from a comparison of the
observations with the Cape, while the same observa-
tions compared with those of Rodrigues and Lisbon
shew that the parallax exceeds 10 seconds. Let us
therefore suppose that the observers at the Cape have
set down their observation one minute too soon, tho'
it must be confessed that the time of the duration at
the egress cannot warrant such a correction, and that
the time of the internal contact should have been ob-
served at 21ʰ.40′.52″; the parallax, by taking a mean,
will then be 9″,732, exactly agreeing with a mean
of all the other determinations. And in this Quan-
tity of the Sun's parallax we must either acquiesce, or
remain as ignorant of the true quantity of it as we
we were before, till we can have recourse to the next
transit on June 3d 1769, when the planet Venus will
again pass over the Sun's disk, having something

more

more than 10 minutes of North latitude ; and will
be fo favourably circumftanced, that, if the errors
in obferving each contact do not exceed 4″ or 5″,
the quantity of the Sun's parallax may be deter-
mined within lefs than $\frac{1}{100}$th part of the whole :
as the total duration, or the interval between the two
internal contacts, will be found to be about 18 mi-
nutes longer at Tornea° than at Mexico. But the
feveral circumftances of that tranfit muft be the fub-
ject of a future paper. Let it fuffice at prefent to ob-
ferve that it will in part be vifible to the inhabitants
of this ifland, as Venus will be feen wholly entered
upon the Sun's difk more than half an hour before
the time of fun-fet at Greenwich.

LVI. *A*