de Akademie zal recipiëren. Van deze gelegenheid, het bestuur mondeling geluk te wensen, wordt een druk gebruik gemaakt.

Daarna blijven leden en genodigden van de Akademie in de hall van het Instituut, waar verversingen worden rondgediend, nog geruime tijd bijeen om zich ongedwongen met elkaar te onderhouden.

Woensdag, 7 mei 1958,

Plechtige zitting in het Koninklijk Instituut voor de Tropen.

Op het programma staan een voordracht door de heer H. Dooyeweerd en de plechtige uitreiking van de Lorentz-medaille van de Afdeling Natuurkunde der Koninklijke Nederlandse Akademie van Wetenschappen aan de Amerikaanse geleerde, Dr. Lars Onsager, hoogleraar in de theoretische natuur- en scheikunde aan de Yale Universiteit te New Haven (Connecticut).

Te elfder ure is een telegram ontvangen van de echtgenote van de heer Onsager, waarin wordt medegedeeld, dat deze geleerde door plotselinge opneming in een ziekenhuis wegens ernstige ziekte verhinderd is de hem toegekende medaille persoonlijk in ontvangst te komen nemen. Thans zal de onderscheiding aan de heer Robert P. Chalker, Amerikaans Consul-Generaal, worden overhandigd, die zich bereid heeft verklaard, haar ten behoeve van zijn verhinderde landgenoot uit handen van de heer F. Zernike, lid van de Lorentz-commissie, te aanvaarden.

Aanwezig zijn naast gewone leden, buitenlandse leden en correspondenten der Akademie en vertegenwoordigers van buitenlandse instellingen, met hun respectievelijke dames, enkele autoriteiten, zoals de Doyen van het Corps consulaire en de Consul-Generaal der Verenigde Staten van Noord-Amerika. De Minister van Onderwijs, Kunsten en Wetenschappen laat zich vertegenwoordigen. Deze genodigden, alsook de vertegenwoordigers van de Koninklijke Nederlandse Chemische Vereniging en de Nederlandse Natuurkundige Vereniging, worden met de leden van de Lorentz-commissie met hun dames vooraf door het Akademiebestuur in de Raadszaal van het Instituut officieel ontvangen, evenals de vorige dag met verschillende andere autoriteiten is geschied.

Om 10.30 uur leidt de voorzitter van deze dag, de heer M. W. Woerdeman, de zitting als volgt in:

Dames en Heren,

mag ik U allen welkom heten op de tweede dag van de feestelijke bijeenkomsten t.g.v. het honderdvijftigjarig bestaan van onze Koninklijke Nederlandse Akademie van Wetenschappen.

Het is een bijzonder grote eer en genoegen voor ons hier welkom te heten de vertegenwoordiger van Zijne Excellentie de Minister van Onderwijs, Kunsten en Wetenschappen.

Nous sommes très heureux, Monsieur le doyen du corps consulaire de vous voir ici.

It is a great pleasure to see you, Mister Consul General of the United States, in our midst.

En verder is het mij een groot genoegen hier welkom te heten de voorzitters van de Koninklijke Nederlandse Chemische Vereniging, en van de Nederlandse

Natuurkundige Vereniging en de leden van de Lorentz-commissie van de Akademie.

Ladies and Gentlemen,

It is with great distress that we have to announce you that Prof. Onsager fell ill on saturday night just before leaving the United States for Amsterdam. The board of the Academy has sent Mr. Onsager a telegram expressing our great distress and wishing him a very complete and rapid recovery. We are glad that the Consul General of the United States has been willing to come to this meeting and to accept the medal on behalf of his compatriot.

Vervolgens geeft hij het woord aan de heer H. Dooyeweerd, hoogleraar aan de Vrije Universiteit te Amsterdam, voor het houden van een voordracht, getiteld: Maatstaven ter onderkenning van progressieve en reactionaire bewegingen in de historische ontwikkeling. De tekst van deze lezing is achter het verslag opgenomen.

Na de lezing van de heer Dooyeweerd betoogt de voorzitter, dat het eigenlijk voor de hand ligt bij een jubileum van een instelling als de Akademie van Wetenschappen, even stil te staan bij de historische ontwikkeling, en de verschillende maatstaven ter onderkenning van progressieve en reactionaire bewegingen in deze geschiedenis te bespreken. Wanneer dit dan, aldus de voorzitter, op een zodanig hoog peil geschiedt als deze morgen, mogen wij de heer Dooyeweerd wel buitengewoon erkentelijk zijn voor zijn bijdrage tot de feestviering.

Alsnu richt de voorzitter zich met de volgende woorden tot de vergadering:

Ladies and Gentlemen,

The famous physicist Lorentz was president of the division of physics and science of the Academy from 1910-1921. In 1926 a national and international committee collected funds to commemorate the work of Lorentz at Leyden University. From this Lorentz-fund part of the capital was given to the Academy in honour of Lorentz to award a medal each of every four years to a physicist working in the field of Lorentz who had done outstanding work in this field.

Our committee has decided that this year the medal should be awarded to Dr. Onsager of Yale University in New Haven, but as I mentioned already Dr. Onsager is not able to be present at this meeting and so we are glad that the Consul General of the United States will represent him and accept the medal on his behalf. Professor Zernike has been willing to explain the reasons of the committee for awarding the medal to Dr. Onsager.

May I now invite Professor Zernike to pronounce his lecture.

De heer F. Zernike, hoogleraar aan de Rijksuniversiteit te Groningen, houdt de volgende redevoering:

Mr. President, Ladies and Gentlemen,

We came here at this hour for the intended solemn presentation of the Lorentz-medal to Dr. Lars Onsager. Although we all regret very much that by ill fate he is prevented from being in our midst, we can all the same honour him by speaking about the special merits of his scientific achievements, for which the medal has been awarded to him. Rather than giving you a general survey of all of Professor Onsager's work, I should prefer to discuss more fully three major subjects which have made his name well-known throughout the scientific world. They are (1) the reciprocal relations for irreversible processes, (2) the electric polarization of liquids, and (3) the order-disorder transitions.

Let us then begin with Professor Onsager's contribution to the subject of the thermodynamics of irreversible processes. In the 1850's the general theory of the transformation of heat into mechanical work was established by abstract reasoning about the ideal efficiency of the steam engine. This developed into a new chapter of physics, called thermodynamics. The general validity of the fundamental law of this discipline can be derived only if the successive changes which the working substance — such as steam — undergoes, can as well be brought about in the reverse order. Because of this, the various relations found by thermodynamics are strictly applicable only to reversible processes.

In a few cases, however, it was tempting to apply thermodynamics to processes in which irreversible changes are fundamentally involved. The first example was given by one of the founders of the new discipline, William Thomson, who deduced new relations for the supply of electric current by thermocouples. Because the conduction of heat from the hot to the cold junction is essentially irreversible, Thomson conceded that his reasoning had to be regarded as intuitive rather than logical, and that the results would need confirmation by experiment.

Theorists are not easily satisfied. Even after some experiments had confirmed Thomson's results, the question of the thermodynamical proof continued to intrigue them. In 1886 Lorentz devoted an extensive paper to such a proof but without much result. In the course of time the theory of other phenomena in which irreversible processes occur was tentatively developed in somewhat the same way; these doubtful treatments are now called "pseudo-thermodynamic".

A comprehensive theory of all these irreversible phenomena was given in 1931 by Prof. Onsager in two fundamental papers about the "reciprocal relations" in irreversible processes. The meaning of these relations can be illustrated by considering the conduction of heat in a crystal. It is well-known that crystalline material generally exhibits different properties in the different directions. Suppose now that there is in a crystal a local temperature inequality. The temperature gradient g_1 in direction 1 causes a proportional flux of heat f_1 equal to $c_1 g_1$. Similarly in direction 2 (perpendicular to 1) the heat flux is $f_2 = c_2 g_2$, the coefficient c_2 being generally different from c_1. And in direction 3 there is a third relation containing another coefficient c_3. However, the conductivity need not be wholly determined by these three coefficients. In a crystal of low symmetry the temperature gradient g_1 may cause a flow in an inclined direction, so that the general equation for the flux f_1 is

$$f_1 = c_{11} g_1 + c_{12} g_2 + c_{13} g_3$$

with similar relations for f_2 and f_3. That is to say that the phenomenon is described by nine coefficients which may be written in a 3×3 square array. Now Onsager proved that quite generally $c_{12} = c_{21}$, etc., so that the conduction phenomenon is described by six rather than nine different numbers. I have chosen the example of anisotropic heat conduction because this case cannot be handled by pseudo-thermodynamics. Indeed you will find that in 1910 in an extensive book "Kristallphysik", W. Voigt states that the three differences $c_{12} - c_{21}$, etc., "determine rotatory qualities, the experimental confirmation of which forms an important problem". Later on he gives five pages of formulae as well as indications for exact experiments which in his own hands had given negative results for two substances. He recommends further searching for this effect in other substances. These remarks show how little convincing experiments are in the absence of a theoretical background. The necessary background would be provided twenty years later in the form of the "reciprocal relations" just mentioned.

I now have to say a few words regarding the theoretical proof of these relations. To begin with, I must recall that there are two clearly separate methods for explaining physical phenomena of matter in bulk. The first one, the continuum method, considers any homogeneous substance — gas, liquid, or solid — as a structureless medium, a continuum, the specific properties of which are known from experiment. The second one, the molecular method, tries to explain the specific properties in terms of the physical properties of the constituent particles — molecules, atoms, and electrons. There is no doubt that this molecular method explains more and goes deeper into the fundamental mechanisms involved. At the same time, however, it is much more complicated and more difficult to handle.

Now returning to Onsager's problem it is clear that he needed to go beyond the strict limits of thermodynamics. The same is the case with all those phenomena where the molecular structure of matter reveals itself on a larger scale, as in the Browwnian movement and other so-called fluctuation phenomena. The secret of obtaining a generally applicable theory in these cases consists of using molecular considerations as little as possible, returning to continuum theory directly after. In other words, one avoids going into a detailed model of the molecules and their interactions, introducing only very general results of molecular theory, such as the law of equipartition and the Boltzmann factor for the probability of spontaneous deviations from equilibrium. Onsager combined the theory of fluctuations with the general principle of microscopic reversibility. Appropriate manipulations with the resulting statistical formulae lead to the general reciprocal relations.

On the basis of the reciprocal relations — which are generally known today as the "Onsager relations" — a new field of physics has developed, known as the "thermodynamics of irreversible processes". Among the more recent scholars working in this area I might mention Professor Prigogine (in Brussels) and Professor S. R. de Groot (in Leyden), both of whom have published monographs on this new extension of thermodynamics. With the help of this new formalism it is now possible to treat in a similar fashion such widely diverse topics as the Peltier heat effect, electro-osmotic pressure, and thermal diffusion; the latter is of practical interest in connection with isotope separation.

Let us now turn to the polarization in liquids; this was an old, apparently well-established subject when Onsager gave a new approach in 1936. The names of Clausius and Mossotti, of the Danish Lorenz and the Dutch Lorentz, and later of Debije were connected with it. Here the splitting up into a molecular and a continuum treatment occurs in a different way. All authors just mentioned have applied molecular considerations to a single molecule, which rotates under the influence of the so-called internal electric field. To find the dependence of this field on the externally applied field the influence of the surrounding medium is taken into account according to the continuum theory. Debije (from 1912 on) had in this way calculated the strength of the permanent dipole for liquids of high dielectric constant. The mechanism may be described in general terms as follows. The internal field tries to align the molecular dipole parallel to it, but is counteracted by the thermal movements. As a result the dielectric constant should increase indefinitely with decrease of temperature. More exactly there should be a critical temperature below which a permanent orientation occurs even without external field. However, this has never been found experimentally.

It is remarkable that Onsager could avoid this breaking down of the theory without having to change the model. He split the internal field into two parts: the cavity field G which is parallel to the external field and the reaction field R caused by the dipole of the central molecule and always parallel to this dipole. The only difference with his predecessors comes from the simple fact that G alone is active in orienting the dipole. The resulting formula does not lead to a critical temperature, and is in good agreement with experiment. Curiously enough this subject too was taken up by a Dutch scientist, namely by Böttcher, who improved the formula by inserting a different value for the radius of the cavity and made extensive studies resulting in a monograph in 1952.

The third subject is about the order-disorder transitions. The phenomenon in its simplest form is as follows. Two metals A and B melted together give a homogeneous alloy, so called mixed crystals. On investigating the structure by X-rays it is ordinarily found that in the regular arrangement of the atoms into the crystal lattice any atom A can arbitrarily be replaced by an atom B. On building up the crystal, the atoms then join together indifferently, with the result that in the mixed crystal the atoms A and B occupy the lattice sites in a random way. In some cases, however — for instance with copper and gold — there is a tendency to an orderly sequence, such that next to an A-atom there is a preference for a B. Let there be equal numbers of A and B atoms, then if the preference is strong enough, there will result a regular alternation, a chess-board pattern, in which every A is adjacent to B's and conversely. The problem is: what is a strong enough preference? Experiment shows that the ordered state forms automatically below a certain temperature T_0, the disordered above that temperature and that the transition between the two is not quite abrupt (so-called transition of the second kind). In the language of thermodynamics the struggle between order and disorder is nothing else than the contest between the binding energy, which tends to a minimum by ordering, and the entropy which tends to a maximum by increasing disorder. According to molecular statistics the problem would be entirely solved if one could calculate the number of possible arrangements of A's and B's for any total number of adjacent A-B pairs. This has not been possible as yet. Theorists at one time came to wonder whether the necessarily simplified model they started with was perhaps so far from the real case that it could no longer show a transition point. Indeed it was proved that in a single row of A and B atoms, i.e. a one-dimensional lattice, there is no such point. The next step evidently is to consider a two-dimensional structure, i.e. an array in a plane. A rigorous treatment of this case was started by Kramers and Wannier in 1940. They succeeded in proving the existence of the transition point and in calculating the value of T_0. The complete solution waited for the genius of Onsager. He published it in a masterly paper of 1944. This memoir is truly incomparable. In it the author ascends to such high summits of abstract mathematics — group theory — that most theoretical physicists cannot possibly follow him, being only able to watch him from afar with respectful awe.

In an altogether too short time I have endeavoured to show the important rôle Dr. Onsager's researches have played in the development of three major objects. Each of these formed the culminating point of large series of researches by his predecessors. Among these I especially note three Dutch physicists, namely H. A. Lorentz, to whose glory this medal was established, Debye, and Kramers, who were the third and the fifth Lorentz medallists. We are very pleased to be able to confer the seventh Lorentz medal upon so worthy a successor as Dr. Onsager.

Nadat de Lorentz-medaille aan hem is overhandigd, zegt de Consul-Generaal van de Verenigde Staten, de heer Robert P. Chalker:

Mister President, Dr. Zernike, Ladies and Gentlemen,

I am confident that Dr. Onsager would wish me to say how deeply he appreciated the honour that has been done to him to-day. I am enforced but not equipped to comment upon the circumstances of the work that has led to this award and I am confident too that there is much regret here to-day that he was not present to give you the benefit of his thinking in his field of activity.

I believe, that he will, if he can, come personally to thank you and it only remains to me to say thank you again and I hope that these meetings will continue in the same high spirit and on the same high intellectual level on which they have begun.

De voorzitter dankt daarop de heer Zernike voor zijn uiteenzetting van de redenen, waarom aan de heer Onsager de Lorentz-medaille is toegekend en de heer Chalker voor zijn bereidheid als vertegenwoordiger van de begiftigde op te treden. Hij verzoekt de consul-generaal, Prof. Onsager de beste wensen van de Akademie voor een spoedig algeheel herstel te willen overbrengen.

De voorzitter deelt de aanwezigen mede, dat de in het jubileumprogramma aangekondigde receptie door afwezigheid van de heer Onsager geen doorgang kan vinden. Hij spreekt de hoop uit, dat het merendeel der genodigden nog gedurende enige tijd met het bestuur in de hall van het Tropeninstituut zal willen vertoeven, waar verversingen worden rondgediend. Hij wijst er voorts op, dat degenen, die daarvoor een deelnemerskaart hebben ontvangen, zich om 13.15 uur naar de speciaal gecharterde gemeentebussen kunnen begeven, die hen naar het gebouw van de Akademie, het Trippenhuis, zullen brengen.

Dan verklaart hij de bijeenkomst voor gesloten.

De receptie des namiddags in het Trippenhuis heeft een zeer geanimeerd verloop.

In enkele vertrekken van het Akademiegebouw zijn buffetten ingericht, door middel waarvan de bezoekers, voor het merendeel leden en correspondenten en vertegenwoordigers van buitenlandse wetenschappelijke instellingen, met hun respectievelijke dames, een wandelende lunch kunnen gebruiken.

Afb. 12 — Prof. F. Zernike tijdens zijn redevoering t.g.v. de toekenning der Lorentz-medaille aan Prof. Lars Onsager, op 7 mei 1958.